UNIVERSITY OF DELHI

CNC-II/093/1/EC-1275/25/4
Dated: 31.07.2025

NOTIFICATION

Sub: Amendment to Ordinance V

(ECR 24-10/ dated 12.07.2025)

Following addition be made to Annexure-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

The syllabi of following Departments under Faculty of Science based on Undergraduate Curriculum Framework 2022 are notified herewith for the information of all concerned :

Department/**College**	**Syllabi**
Environmental Studies	B.Sc. (Hons.) Environmental Science (Semester VII/VIII)– **Annexure-1**
Physics & Astrophysics	1. B.Sc. (Hons.) Physics (Semester VII/VIII)- **Annexure -2** 2. B.Sc. Physical Science with Physics as one of the Core & B.Sc. Physical Science with Physics & Electronics as one of the Core Disciplines (Semester-VII/VIII) – **Annexure -3** 3. B.Sc. Physical Science with Electronics as major (Semester-VII/VIII) **Annexure-4**
Holy Family College of Nursing	Revised B.Sc. Nursing (Post Basic)- **Annexure -5**
Botany	B.Sc. Life Science with Botany as Major (Sem-VII/VIII)– **Annexure-6**
Zoology	1. Generic Electives papers offered by the Department of Zoology under Faculty of Science for Semester VII and VIII – **Annexure-7** 2. BSc. Life Science with Zoology as Major (Sem-VII/VIII) – **Annexure-8**
Chemistry	1. B.Sc. (H) Chemistry – **Annexure-9** 2. B.Sc. Industrial Chemistry – **Annexure-10** 3. B.Sc. Polymer Chemistry – **Annexure-11** 4. B.Sc. Analytical Chemistry – **Annexure-12** 5. B.Sc. Physical Science with Chemistry as Major– **Annexure-13** 6. B.Sc. Life Science with Chemistry as Major– **Annexure-14**
B.Sc. Applied Life Science with Agrochemical and Pest Management -	1. Zoology Component (Sem-VII/VIII) 2. Botany Component (Sem-VII/VIII) 3. Chemistry Component (Sem-VII/VII **Annexure-15**

31/7/25

REGISTRAR

Semester – VII

COURSES OFFERED BY DEPARTMENT OF ENVIRONMENTAL SCIENCE

Category-I

Environmental Science Courses for Undergraduate Programme of study with Environmental Science as a Single Core Discipline

BSC (H) ENVIRONMENTAL SCIENCE

DISCIPLINE SPECIFIC CORE COURSE – 19 (DSC-EVS-19): METHODS IN ECOLOGICAL RESEARCH

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-19: METHODS IN ECOLOGICAL RESEARCH	4	2	0	2	Class XII pass	NA

Learning objectives
The Learning Objectives of this course are as follows:
- Equip with principles and methods of ecological research and acquire a broad understanding of its different subfields
- Understand the ethical considerations involved with technological approach used in ecological research
- Familiar with how to design and conduct ecological research in laboratory or in field environment
- Introduce with emerging approaches and tools in different types of ecological research

Learning outcomes
After this course, students will be able to:
- Design and implement experiments for different types of ecological research and explain the steps involved in hypothesis testing
- Use appropriate sampling strategy to collect data and conduct observational studies in ecological research
- Analyze and interpret ecological data using appropriate statistical methods
- Evaluate the strengths and limitations of different tools, methods and techniques for different types of ecological research

SYLLABUS OF DSC-EVS-19

Theory (02 Credits: 30 hours)

Unit 1: Basics of Ecological Research and Scientific Method (7 hours)
Overview of ecological research methods; Scientific method and hypothesis testing; Experimental design and field sampling techniques; Data collection methods: quadrats, transects, plot sampling; Introduction to ecological data types; Ethical considerations in ecological research; Scientific communication and reporting.

Unit 2: Biodiversity, Conservation, and Behavioral Ecology Methods (8 hours)
Biodiversity measurement: species richness, diversity indices; Conservation planning and prioritization; Methods for assessing endangered and invasive species; Habitat mapping and classification; Basic restoration monitoring approaches; Behavioral observation and recording; Bioacoustics and movement tracking; Introduction to behavioral data analysis.

Unit 3: Population and Community Ecology Methods (7 hours)
Population dynamics: growth models, density estimation; Mark-recapture techniques; Species abundance and distribution estimation; Methods for studying competition and niche partitioning; Mutualism and basic co-evolutionary interactions; Introduction to genetic diversity (molecular markers, no phylogeny); Field-based adaptation studies.

Unit 4: Ecosystem and Landscape Ecology Methods (8 hours)
Remote sensing and GIS for ecological mapping (introductory); Carbon and nutrient cycling measurements; Ecosystem function and service assessment tools; Basic hydrology and water quality monitoring; Monitoring climate change impacts on ecosystems; Fundamentals of ecological restoration and management; Introduction to ecological data analysis and visualization (basic stats, charts).

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Use random quadrat sampling to measure species richness and abundance of herbaceous plants in a campus or nearby green area.

2–3. Practice belt and line transect methods to assess population density or diversity of plants or insects in two different habitats (e.g., lawn vs. woodland).

4. Create a basic habitat map of a local area (e.g., college campus or park) using freely available GIS tools (e.g., QGIS) and mark observed presence of a common species.

5–6. Use open-source land use data (e.g., Bhuvan, Google Earth) to assess changes in land cover and relate it to species observations or known distributions.

7. Conduct a behavioral observation session on birds or urban animals (e.g., squirrels, dogs), record focal behavior and analyze simple patterns (time budgets, frequencies).
8. Observe and record foraging behavior of birds (e.g., pigeons, crows) and test basic hypotheses of niche use or resource sharing.
9. Set up a simple pot experiment to test the effect of different fertilizers (e.g., compost, chemical) on seedling growth of a common plant.
10. Use Google Earth or open GIS data to identify and measure landscape fragmentation (e.g., green patches, built-up areas) in the college surroundings.
11. Construct a basic plant family tree using morphological characters or literature data for a group of local plant species (e.g., Fabaceae, Asteraceae).
12. Use secondary data (e.g., herbarium records, published sources) to map the biogeographic distribution of a group of native or invasive plants in the region.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Essential/recommended readings

- Pardo, S. and Pardo, M., 2018. Statistical methods for field and laboratory studies in behavioral ecology. Chapman and Hall/CRC.
- Jørgensen, S.E., 2009. Ecological modelling: an introduction. WIT press.
- Gotelli, N. J., & Ellison, A. M. (2004). A primer of ecological statistics (2nd ed.). Sinauer Associates.
- Zuur, A. F., Ieno, E. N., & Smith, G. M. (2007). Analyzing ecological data. Springer Science & Business Media.

Suggestive readings

- Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L., 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford university press.
- Krebs, C. J. (2016). Ecology: the experimental analysis of distribution and abundance (6th ed.). Pearson.
- Van Dyke, F., 2008. Conservation biology: foundations, concepts, applications. Springer Science & Business Media.
- Zuur, A. F., Ieno, E. N., & Saveliev, A. A. (2017). Beginner's guide to spatial, temporal and spatial-temporal ecological data analysis with R-INLA. Highland Statistics Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Semester – VIII

DISCIPLINE SPECIFIC CORE COURSE – 20 (DSC-EVS-20): ENVIRONMENTAL STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-20: ENVIRONMENTAL STATISTICS	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into application of probability theory in solving environmental problems
- Explore environmental data using descriptive and inferential statistics
- Understand regression analysis for determining environmental relationships
- Equip with methods of analyzing time series data and identify trends in environment
- Practice spatial statistics to identify spatial patterns in environmental variables

Learning outcomes

After this course, students will be able to

- Apply probability theory to assess risks in environment
- Analyze and visualize environmental data using descriptive statistics and graphicalmethods
- Formulate and test hypotheses to understand problems in environmental science
- Apply regression analysis to decipher the relationships between different sets ofenvironmental variables
- Analyze time series data and spatial statistics to identify trends and spatialrelationships among different variables

Unit 1: Basics of Environmental Statistics and Probability (7 hours)
Definition, scope, and applications of environmental statistics; Types of environmental data, sampling and data collection; Data exploration and basic visualization (boxplots, histograms); Introduction to probability theory, conditional probability, and independence; Overview of random variables and probability distributions in environmental applications.

Unit 2: Descriptive Statistics and Data Relationships (7 lectures)
Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation, variance); Skewness, kurtosis, and graphical summaries; Correlation and covariance; Introduction to Spearman's rank correlation; Conceptual introduction to principal components (without calculation).

Unit 3: Hypothesis Testing and Regression Analysis (8 hours)
Formulating null and alternative hypotheses; Type I and II errors; Parametric tests: t-test (one-sample and two-sample), Chi-square test (goodness of fit, independence), and one-way ANOVA; Introduction to simple linear regression and its applications in environmental management.

Unit 4: Time Series, Non-Parametric Methods, and Spatial Basics (8 hours)
Basics of time series data: trend, seasonality, decomposition (qualitative understanding); Introduction to forecasting applications in environment; Non-parametric tests: Mann-Whitney U, Wilcoxon signed-rank, Kruskal-Wallis (concepts and application); Introduction to spatial data types and environmental relevance (without deep geostatistics or spatial modeling).

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b)Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Visualize an environmental data set using descriptive statistics and graphicalmethods
2. Estimate risk for a given environmental hazard using probability distributions
3. Use one-sample t-test and test a hypothesis about a population parameter andinterpret the results.
4. Test a hypothesis about the difference between multiple population means usingANOVA
5. Analyze environmental data using a linear regression model and interpret thecoefficients and goodness of fit
6. Analyze the given time series data set using trend analysis or analyze a spatialdata set using spatial regression models
7. Use cluster analysis to group environmental samples based on their similarities.

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratorypracticals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Cressie, N. A. C., & Wikle, C. K. (2011). Statistics for spatio-temporal data. JohnWiley & Sons.
- Gotelli, N. J., & Ellison, A. M. (2004). A primer of ecological statistics. SinauerAssociates.
- Hoshmand, R., 2017. Statistical methods for environmental and agriculturalsciences. CRC press.
- Millard, S.P., 2013. EnvStats: an R package for environmental statistics. SpringerScience & Business Media.
- Qian, S.S., 2016. Environmental and ecological statistics with R. Chapman and Hall/CRC.

Suggestive readings

- Brown, J. A., & Lovett, G. M. (2018). Spatial models for environmental andecological data. CRC Press.
- Clark, J.S. and Gelfand, A.E. eds., 2006. Hierarchical modelling for the environmentalsciences: statistical methods and applications. OUP Oxford.
- Helsel, D. R. (2012). Statistics for censored environmental data using Minitab and R.John Wiley & Sons.
- Hoshmand, R., 2017. Statistical methods for environmental and agriculturalsciences. CRC press.
- Fletcher, R. and Fortin, M., 2018. Spatial ecology and conservation modeling (p.523). Cham: Springer International Publishing.

Note: Examination scheme and mode shall be as prescribed by the ExaminationBranch, University of Delhi, from time to time.

Annexure-2

DEPARTMENT OF PHYSICS AND ASTROPHYSICS

Undergraduate Curriculum Framework 2022

B.Sc. (Hons) Physics

Semester VII and VIII

***Implemented for the Academic Session 2025-26 only**

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC CORE COURSE – DSC 19: CLASSICAL MECHANICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Classical Mechanics DSC 19	4	3	1	0	DSC – 2 (Mechanics)

COURSE OBJECTIVES

- To introduce variational principles and their application to derive equations of motion for complex systems with constraints.
- To deepen the understanding of foundational principles of Classical Mechanics including Lagrangian and Hamiltonian formalisms
- To Develop an understanding of symmetries and conservation laws through Noether's Theorem
- To develop analytical skills to solve problems in dynamics, including those involving rigid bodies.
- To analyze the motion of particles in central force fields, and understand orbital mechanics, including scattering phenomena.
- To introduce theory of small oscillations, enabling students to analyze stability and coupled oscillatory systems.

LEARNING OUTCOMES

By the end of this course, students will be able to:

- Apply the calculus of variations to derive the Euler-Lagrange equations and use them to analyze constrained mechanical systems.
- Formulate and analyze mechanical systems using Lagrangian and Hamiltonian formalisms.
- Apply the principles of symmetry and conservation laws through Noether's theorem.
- Analyze motion in phase space and construct phase portraits
- Understand the dynamics of rigid bodies.
- Analyze the motion of particles under central forces and solve scattering problems.
- Understand and compute normal modes and normal frequencies in small oscillation problems.
- Develop critical thinking and problem-solving skills

SYLLABUS OF DSC 19
THEORY COMPONENT
(Hours: 45)

Unit I (10 Hours)

Variational Principle and Lagrangian Formulation
Calculus of Variation with applications. Generalized coordinates. Lagrangian, Hamilton's Principle, Euler-Lagrange equations of motion. Constrained systems. Cyclic coordinates and conserved quantities. Applications to physical systems.

Unit II (10 Hours)

Hamiltonian Formulation and Phase Space
Legendre transformation, Hamilton's equations of motion. Phase space, phase trajectories, Phase portraits. Canonical transformations, Poisson brackets, Liouville's theorem and conservation of phase space volume. Applications to Physical Systems.

Unit III (11 Hours)

Rigid Body Dynamics
Rotation Matrices, Euler Angles. Angular momentum and kinetic energy of rigid bodies, The Inertia Tensor, Principal Axis Transformation. Euler's equations of motion for rigid body. Torque-free motion. The symmetrical top with one point fixed.

Unit IV (14 Hours)

Central Force and Orbital Mechanics
Equation of motion under central force, Classification and Stability of orbits**.** Virial Theorem. Bertrand's Theorem. The Kepler Problem. Scattering in central force field, Rutherford scattering.
Theory of small oscillations: Linearization of equations of motion. Principal Axis Transformation, Normal mode analysis of forced and coupled oscillators.

REFERENCES

Essential Readings

1. Classical Mechanics, H. Goldstein, C. P. Poole, J. L. Safko, 3/e, Pearson Education (2014).
2. Classical Mechanics, John R. Taylor, University Science Books (2005).
3. Classical Mechanics, R. Douglas Gregory, Cambridge University Press (2015).
4. Mechanics, L. D. Landau and E. M. Lifshitz, Pergamon (2010).
5. Classical Mechanics, P. S. Joag, N. C. Rana, McGraw Hall Education (2017).
6. Classical Dynamics of particles and system, S. T. Thornton, J. B. Marion, Cengage Learning (2012).

7. Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, McGraw Hill Education (1997).

Additional Readings

1. Classical Mechanics, Tai L. Chow, CRC Press (2013).
2. Analytical Mechanics: Solutions to Problems in Classical Physics, I. Merches, D. Radu, CRC Press (2015).
3. Solved Problems in Classical Mechanics, O. L. Delange and J. Pierrus, Oxford University Press (2010).
4. Mathematical Methods of Classical Mechanics**,** V.I. Arnold, Springer Nature (1989).
5. Classical Mechanics: A course of lectures, A K Raychoudhuri, Oxford University Press (1984).

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 9: ADVANCED MATHEMATICAL PHYSICS II

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Advanced Mathematical Physics II DSE 9	4	3	1	0	Mathematical Physics-I and Mathematical Physics-II of this course or Equivalent courses

COURSE OBJECTIVES

The emphasis of the course is to acquire advanced mathematical inputs while solving problems of interest to physicists. The course aims to introduce the students to the principles of tensor analysis and equip them to use the concept in modelling of continuous media, electrodynamics, elasticity theory and the general theory of relativity. The mathematical skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will,

- Have a knowledge and understanding of tensor analysis and tensor calculus
- Be able to do computation with tensors, both in coordinates and in coordinate-free form.
- Understand the transformation properties of covariant, contravariant and mixed tensors under general coordinate transformation.
- Be able to apply the concepts of tensors in anisotropic media with examples of moment of inertia tensor, elasticity tensor and polarizability tensor.
- Understand physical examples of tensors such as Moment of Inertia and Elasticity of asymmetrical physical systems.
- Be able to write down the Lorentz Transformation in four vector notation.
- Understand inner product and outer product of general tensors.
- Understand the concept of covariant derivatives.

SYLLABUS OF DSE 9
THEORY COMPONENT
(Hours:45)

Unit I **(12 Hours)**

Cartesian Tensors: Transformation of co-ordinates under rotation of axes. Einstein's Summation Convention. Relation between direction cosines. Transformation Law for a tensor of rank *n*. Sum, inner product and outer product of tensors, contraction of tensors, Quotient Law of tensors, symmetric and anti-symmetric tensors. Invariant tensors (Kronecker and Alternating Tensor). Association of anti-symmetric tensor of rank two with vectors. Vector algebra and calculus in tensor notation. Differentiation, gradient, divergence and curl of Tensor Fields. Vector Identities in tensor notation

Unit II **(12 Hours)**

Applications of Cartesian Tensors: Equation of a Line, Angle between Lines, Projection of a Line on another Line, Condition for Two Lines to be Coplanar and Length and Foot of the Perpendicular from a Point on a Line. Rotation Tensor and its properties.

Moment of Inertia Tensor, Stress and Strain Tensors, Elasticity Tensor, Generalized Hooke's Law, Electric Polarizability.

Unit III **(9 Hours)**

General Tensors: Transformation of co-ordinates and contravariant and covariant vectors. Transformation law for contravariant, covariant and mixed tensors. Kronecker Delta and permutation tensors. Algebra of general tensors. Quotient Law general tensors. Symmetric and anti-symmetric tensors. Metric Tensor. Reciprocal Tensors. Associated Tensors.

Unit IV **(12 Hours)**

Christoffel Symbols of first and second kind and their transformation laws. Covariant derivative, gradient, divergence and curl of tensor fields. Minkowski Space, Four Vectors (four-displacement, four-velocity, four-momentum, four- vector potential, four- current density,). Tensorial form of Lorentz Transformation.

REFERENCES

Essential Readings

1) Vector Analysis and Cartesian Tensors, 3rd edition, D. E. Bourne, P. C. Kendall, 1992
2) Cartesian Tensors, H. Jeffreys, 1931, Cambridge University Press.
3) Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, 2010, Elsevier.
4) A Brief on Tensor Analysis, J. G. Simmonds, 1997, Springer.
5) Schaum's outlines series on Vector Analysis, M. Spiegel, 2nd edition, 2017.

6) Schaum's Outline Series on Tensor Calculus, D. Kay, Revised 1st edition, 2011.
7) An Introduction to Tensor Calculus and Relativity, D. F. Lawden, 2013, Literary Licensing
8) Matrices and tensors in physics by A. W. Joshi, 1995, New Age International Publications.

Additional Readings

1) A Student's Guide to Vectors and Tensors, D. A. Fleisch, 2011, Cambridge Univ. Press.
2) The Feynman Lectures on Physics, Volume II, Feynman, Leighton and Sands, 2008, Narosa Publishing House.
3) Classical Electrodynamics, J. D. Jackson, 3rd edition, 2009, Wiley Publication.
4) A Primer in Tensor Analysis and Relativity, I. L. Shapiro, 1st edition, 2019, Springer.
5) Gravity-An introduction to Einstein's General Relativity, J. B. Hartle, 2009, Pearson Education.
6) A first course in general relativity, B. F. Schutz, 2004, Cambridge University Press

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 12: ADVANCED MATHEMATICAL PHYSICS - III

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Advanced Mathematical Physics – III DSE 12	4	3	1	0	Knowledge of Linear Algebra will be helpful.

COURSE OBJECTIVES

- To understand and apply Laplace transforms to solve ordinary differential equations, particularly in physical systems like electric circuits.
- To learn the formulation and application of Green's functions in solving linear differential equations, including partial differential equations in two and three dimensions.
- To grasp the foundational principles of group theory, including finite and continuous groups, and understand how these abstract structures underlie symmetries in physics.

LEARNING OUTCOMES

After completing the course the students will be able to

- Compute Laplace transforms and inverse transforms of a variety of functions.
- Use Laplace transforms to solve second-order ordinary differential equations with physical relevance (e.g. electric circuits).
- Work with finite permutation groups and construct matrix representations.
- Understand the structure and representations of continuous groups and apply group theoretical methods to angular momentum algebra and quantum mechanical symmetries.
- Construct Green's functions for linear differential operators and use them to solve inhomogeneous ODEs and PDEs.
- Understand the physical interpretation of Green's functions in electrostatics, vibrations, and wave propagation.

SYLLABUS OF DSE 12
THEORY COMPONENT
(Hours: 45)

Unit I **(15 Hours)**

Laplace Transforms
Integral transform and kernels. Definition and Condition for Existence of Laplace Transform (LT), LT of Elementary Functions, Properties of LT. LTs of Derivatives and Integrals of Functions and Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function and Periodic Functions. Convolution Theorem. Inverse LT: Properties of inverse LT, Methods of finding inverse Laplace transforms. Solution of nonhomogeneous linear constant coefficient differential equations using LT.

Unit II **(14 Hours)**

Green's Function
Green's functions for one-dimensional problems (ODEs), construction of Green's function, Application of Green's function in initial and boundary value problems, Green's function for two and three dimensional problems (PDEs). Green's function for the Laplacian operator, Solution of Poisson's Equation in three dimensions using Green's function. Green's function for wave operator, solution of wave equation in (1+1) and (2+1) dimensions using Green's function. Solution of Diffusion Equation in (3+1) dimensions using Green's function.

Unit III **(8 Hours)**

Basics of Group Theory
Groups and properties of groups, Cayley table, Subgroups, cyclic group, centre of a group, Cosets of a subgroup. Lagrange Theorem (No derivation). Homomorphism and Isomorphism of groups, Normal and conjugate subgroups. Permutation group, Cayley Theorem (no proof). Matrix representation of groups.

Unit IV **(8 Hours)**

Continuous groups
Rotation group SO(2) and its representations. Unitary groups U(1), SU(2) and their Representations, Pauli matrices as SU(2) generators and their algebra. Application to angular momentum operators, spin systems and symmetry transformations in quantum mechanics.

REFERENCES

Essential Readings

1. Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, Elsevier (2010).
2. Mathematical Methods for Physics and Engineering, K. F. Riley, M. P. Hobson, S. J. Bence, Cambridge University Press (2006).
3. Mathematical Physics with Applications, Problems and Solutions, V. Balakrishan, Ane Books (2017).

4. Schaum's Outline of Theory and Problems of Laplace Transforms, Murray R. Spiegel, McGrawHill (2005).
5. An Introduction to Laplace Transform and Fourier Series, Phil Dyke, Springer Nature (2014).
6. https://math.libretexts.org/Bookshelves/Differential_Equations/Introduction_to_Partial_Differential_Equations_(Herman)/07%3A_Green's_Functions.
7. Green's Functions, G. F. Roach, Cambridge University Press (1992).
8. Green's Functions in Classical Physics, Tom Rother, Springer International Publishing (2017).
9. Group Theory and its Applications to Physical Problems, by Morton Hamermesh, Dover Publications (1989).
10. Elements of Group Theory for Physicists, by A. W. Joshi, John Wiley (1997).

Additional Readings

1. Mathematical Methods for Physicists: A Concise Introduction, Tai L. Chow, Cambridge University Press (2000).
2. Introduction to Mathematical Physics: Methods and Concepts, Chun Wa Wong, Oxford University Press (2012).
3. Green's Functions with Applications, Dean G. Duffy, Chapman & Hall/CRC (2001).
4. Advanced Engineering Mathematics with MATLAB, D.G. Duffy, CRC Press (2017).
5. Group Theory and Physics, S. Sternberg, Cambridge University Press (1994).
6. Group Theory and Quantum Mechanics, Michael Tinkham, Dover Publications (2003).
7. Lie Algebras in Particle Physics, H. Georgi, CRC Press (1999)

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 13
ADVANCED QUANTUM MECHANICS - I

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Advanced Quantum Mechanics-I DSE 13	4	3	1	0	Quantum Mechanics-I (DSC 14), Mathematical Physics III (DSC 7) or equivalent courses. Knowledge of Linear Algebra will be helpful.

COURSE OBJECTIVES

- Equips students with the mathematical tools enabling them for transition from concrete wavefunction-based methods to the general abstract formalism of non-relativistic quantum mechanics.
- Presents the full dynamical structure of quantum theory, including both Schrödinger and Heisenberg pictures of time evolution, and introduce the density matrix formalism for describing mixed and entangled states.
- Formally analyzes angular momentum in quantum mechanics, with an emphasis on operator methods, spin, and the addition of angular momentum using Clebsch–Gordan coefficients.

LEARNING OUTCOMES

At the end of this course, students will be able to

- Appreciate the necessity of abstract state vector formalism and articulate the meaning of each postulate of quantum mechanics.
- Solve time-dependent problems using both Schrödinger and Heisenberg pictures.
- Understand and compute time evolution in both ket and operator formalisms.
- Construct and interpret density matrices for pure and mixed states.
- Use ladder operator techniques and commutation relations to solve angular momentum problems and analyse spin systems.
- Apply the Pauli exclusion principle in the context of multi-fermion systems.
- Determine the angular momentum of a composite state using the concept of addition of angular momentum and C.G. coefficients.

<u>SYLLABUS OF DSE 13</u>
<u>THEORY COMPONENT</u>
(Hours: 45)

Unit I **(13 Hours)**

Abstract formulation of Quantum Mechanics
Motivation for developing a linear vector space formulation to describe quantum phenomena. Brief review of linear vector spaces with Dirac's ket notation, Inner product and norm, Schwarz Inequality. Dual space and Bra vectors. Orthonormal basis. Infinite dimensional (discrete) vector space. Hilbert Space of state vectors. Completeness. Dynamical observables as linear operators, Adjoint of a linear operator, Hermitian or self-adjoint operators, eigenvalues and eigenvectors. Projection operator and complete set of basis. Matrix representation of state vectors and operators. Unitary operators and change of basis.

Unit II **(13 Hours)**

Postulates, Measurement and Observables
Postulates of quantum mechanics. Continuous basis, position and momentum representations. Degenerate eigenvalues and complete set of commuting observables. Generalized uncertainty principle.
Quantum Dynamics
Unitary time-evolution, Schr**ö**dinger equation in ket notation and correspondence with wave mechanics. Momentum as generator of translation in space and Hamiltonian as generator of translation in time. Schrödinger vs Heisenberg picture. Evolution of a system in Heisenberg picture with example of simple harmonic oscillator. Classical Limit.

Unit III **(12 Hours)**

Angular Momentum: Abstract operator approach to angular momentum, Commutation Relations. Ladder operators, Matrix representation of angular momentum operators and ladder operators, Eigenvalues and eigenvectors.
Pauli matrices and their properties. Matrix representation of Spin angular momentum operators. Eigenvalues, eigenvectors of $\boldsymbol{S^2}$ and $\boldsymbol{S_z}$ for spin1/2 and spin 1 systems and General spin state for these systems.
Addition of angular momentum: Clebsch-Gordan coefficients, C. G. coefficients of addition for j = (i) 1/2, 1/2; (ii)1/2, 1 and (iii) 1, 1 systems.

Unit IV **(7 Hours)**

Density matrix Formalism
Density operator and matrix, pure and mixed states, expectation value of an observable, time evolution of density matrix, Reduced density matrix for subsystems of a composite system with example of entangled spin-1/2 pair.
Identical particles: Many-particle systems, Exchange degeneracy, concept of parity, symmetric and anti-symmetric wavefunctions. Pauli exclusion principle.

REFERENCES

Essential Readings

1. Introduction to Quantum Mechanics, D.J. Griffith, Pearson Education (2005).
2. Principles of Quantum Mechanics by R. Shankar (Springer, 3rd Edition, 2008)
3. Quantum Mechanics, B. H. Bransden and C. J. Joachain, Prentice Hall (2000).
4. Modern Quantum Mechanics, J. J. Sakurai and Jim Napolitano, Cambridge University Press (2021).
5. Quantum Mechanics: Theory and Applications, Ajoy Ghatak and S. Lokanathan, Laxmi Publications (2019).

Additional Readings

1. Introduction to Quantum Mechanics, Volume-I and II, C. Cohen-Tannoudji
2. The Principles of Quantum Mechanics, P.A.M. Dirac, Clarendon Press, Oxford (1981).
3. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed., 2010, McGraw Hill.
4. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications, 1966.
5. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
6. Quantum Mechanics, Eugene Merzbacher, 2004, John Wiley and Sons, Inc.
7. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer.
8. Introductory Quantum Mechanics, R. L. Liboff; 4th Ed., Addison Wesley, 2003.
9. Angular Momentum in Quantum Mechanics, A. R. Edmonds, Princeton University Press (1996).
10. Elementary Theory of Angular Momentum, M. E. Rose, Dover Publications Inc. (2003)

ADVISORY

The course, Advanced Quantum Mechanics-I, is essential for several courses offered in the one-year M.Sc. program and is also included in the syllabi of various competitive examinations, including CSIR-NET, JEST, and GATE.
Colleges are advised to offer this as a Discipline Specific Elective (DSE). Students who intend to pursue postgraduate studies or appear for competitive exams are strongly encouraged to choose this course as a DSE.

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 14
ATMOSPHERIC PHYSICS AND CLIMATE CHANGE

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Atmospheric Physics and Climate Change DSE 14	4	3	0	1	

COURSE OBJECTIVES

This course familiarizes the students with the atmospheric processes, and vertical thermal and dynamical features in the lower and middle atmosphere. It enables to learn remote sensing techniques to explore atmospheric processes and helps to understand long term oscillations and fluid system dynamics which control climate change. Also, it delineates characteristics of pollutants and aerosols variability in the lower and middle atmosphere. Another important aspect would be how the different atmospheric and meteorological parameters are changing over a period of time from Climate change perspective.

LEARNING OUTCOMES

By successfully completing this course students will be able to,

- Have an overview of thermal structure of the Earth's atmosphere as well as various dynamical processes occurring in different layers of the atmosphere.
- Develop an understanding of remote sensing techniques such as radar, satellite, and lidar systems.
- Understand the origin of different atmospheric oscillations, which are prominent at different altitudes. In addition, understating will be improved on several features of low- and high-pressure systems and wind circulation.
- Atmospheric and Ocean interaction can be learnt how they influence each other on long term time scales connected with such as El Niño Southern Oscillations (ENSO)
- Climate Change can be understood by using long term atmospheric data (both observations and model) and further exploring and utilization of different numerical techniques for the fine and long-term temporal and regional to global scales.
- Develop the problem-solving skills using observations and conducting simulations. This would clarify the fundamental processes and modifications under different conditions.

SYLLABUS OF DSE 14
THEORY COMPONENT
(Hours: 45)

Unit I **(10 Hours)**

General features of Earth's atmosphere
Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms. Dynamics of Particulate Matter (PM), pollutants and meteorological parameters diurnal, seasonal and annual variability. PM and their effect on human health.

Unit II **(13 Hours)**

Atmospheric Dynamics
Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale and general circulations.
Atmospheric Waves
Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration.

Unit III **(7 Hours)**

Remote Sensing Techniques (Atmospheric Radar)
Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Classification and properties of aerosols, Aerosol studies using Lidars.

Unit IV **(15 Hours)**

Climate Change
Historical trends of CO_2 and temperature, understanding on sea level rise. Thermodynamics in climatology, long term energy balance and cycles, and rudimentary introduction to climate change models. Physical processes of greenhouse gases warming the planet, Impact of climate change in extreme weather, regional case studies focus on India subcontinent, Climate policies and international agreement - UNFCCC, Kyoto Protocol, Paris Agreement, Role of COP meetings, Concept of Net-Zero Emission, and Climate Change and public health.

PRACTICAL COMPONENT: ATMOPHERIC PHYSICS AND CLIMATE CHANGE (Hours: 30)

Atmospheric Physics: Scilab/Python/Matlab based simulations experiments based on Atmospheric Physics problems listed below.
At least 03 Experiments from the following should be conducted.

1. Numerical Simulation for atmospheric waves using dispersion relations for
    a. Atmospheric gravity waves (AGW)
    b. Kelvin waves
    c. Rossby waves, and
    d. mountain waves.
2. Processing of radar data a. VHF radar, b. X-band radar, and c. UHF radar,
3. Offline and online processing of LIDAR data.
4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe. Suggested parameters calculations are (i) Brunt Vaisala frequency, (ii) potential temperature, (iii) pressure-height conversion, and (iv) thermal wind equation.
5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique

Climate Change

i. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change.
ii. PM 2.5 measurement using compact instruments and experience with data from CPCB and DPCC to investigate the Climate Change.

Field visits to National centre for medium range weather forecasting, India meteorological departments, and ARIES Nainital to visualise onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

REFERENCES

Essential Readings for the Theory Component

1. Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3 rd edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

Additional Readings for the Theory Component

1. Stratosphere Troposphere Interactions - K Mohanakumar, Springer Netherlands, 2008.
2. Climate change in the Himalayas, Springer publication, by GB Pant, P Pradeep Kumar, J V Revadekar, Narendra Singh, 2018.
3. PM2.5 diminution and haze events over Delhi during the COVID-19 lockdown period: an interplay between the baseline pollution and meteorology, Nature- Scientific Reports, 10(13442). https://doi.org/10.1038/s41598- 020-70179-8., S. K. Dhaka,

Chetna, V. Kumar, V. Panwar, A. P. Dimri, N. Singh, P. K. Patra, Y. Matsumi, M. Takigawa, and T. Nakayama (2020)

4. Gravity wave generation in the lower stratosphere due to passage of the typhoon 9426 (Orchid) observed by the MU radar at Shigaraki (34.85 N, 136.10 E), SK Dhaka, M Takahashi, Y. Shibagaki, MD Yamanaka, S Fukao, Journal of Geophysical Research: Atmosphere 108 (D19), 2003.
5. Indian MST radar observations of gravity wave activities associated with tropical convection, SK Dhaka, PK Devrajan, Y Shibagaki, RK Choudhary, S Fukao, Journal of Atmospheric and Solar-Terrestrial Physics 63 (15), 1631-1642.
6. Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques (https://www.narl.gov.in)

References for the Practical Component

Data sources for radar, lidar, satellite and radiosondes

1. https://www.narl.gov.in
2. http://www.imd.gov.in
3. https://www.ncmrwf.gov.in/
4. https://www.aries.res.in/
5. http://www.rish.kyoto-u.ac.jp/ear/index-e.html

<u>**B.Sc. (Honours) Physics**</u>

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 15
NANOSCIENCE

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Nanoscience DSE 15	4	2	0	2	

COURSE OBJECTIVES

The syllabus introduces the basic concepts of nanomaterials, their synthesis, properties exhibited by them and finally few applications. Various nanomaterial synthesis/growth methods and characterizations techniques are discussed to explore the field in detail. The effect of dimensional confinement of charge carries on the electrical, optical and structural properties will be discussed. Interesting experiments which shape this filed like conductance quantization in 2DEG (Integer Quantum Hall Effect) and coulomb blockade are introduced. The concept of micro- and nano- electro mechanical systems (MEMS and NEMS) and important applications areas of nanomaterials are discussed.

LEARNING OUTCOMES

On successful completion of the course students should be able to

- Explain the difference between nanomaterials and bulk materials and their property difference.
- Explain various methods for the synthesis/growth of nanomaterials.
- Explain the role of confinement on the density of state function and so on the various properties exhibited by nanomaterials compared to bulk materials.
- Explain the concept of Quasi-particles such as excitons and how they influence the optical properties.
- Explain the direct and indirect bandgap semiconductors, radiative and non-radiative processes and the concept of luminescence.
- Explain the structure of 2DEG system and its importance in quantum transport experiments, like Interger Quantum Hall Effect and conductance quantization.
- Explain the conductance quantization in 1D structure and its difference from the 2DEG system.
- Explain the necessary and sufficient conditions required to observe coulomb blockade, single electron transistor and the scope of these devices.
- Explain how MEMS and NEMS devices are produced and their applications.

SYLLABUS OF DSE 15
THEORY COMPONENT
(Hours: 30)

Unit I **(11 Hours)**

Introduction

Basic Introduction to Nano-Science and Technology - Implications on nanoscience on fields like Physics, Chemistry, Biology and Engineering, Classifications of nanostructured materials as quantum dots (0D), nanowires (1D), Thin films (2D) and Multi-layered materials or super lattices. Introduction to properties like Mechanical, Electronic, Optical, Magnetic and Thermal properties and how they change at Nano scale dimensions to motivate students (qualitative only).

Nanoscale Systems

Brief review of Schrodinger equation and its applications in- Infinite potential well, potential step and potential box problems, Band Structure and Density of states of 3D and 2D systems in detail and qualitatively for 1D and 0D, confinement of charges in nanostructures their consequences on electronic and optical properties.

Unit II **(10 Hours)**

Properties of Nano Scale systems

Time and length scales (diffusion, elastic and inelastic lengths etc.) of electrons in nanostructured materials, Carrier transport in nanostructures: diffusive and ballistic transport.

2D nanomaterials: Conductance quantization in 2DEG in GaAs and integer quantum hall effect (semi-classical treatment)

1D nanomaterials: Conductance quantization in 1D structures using split gate in 2DEG system (Qualitative).

0D nanomaterials: Charging effect, Coulomb Blockade effect, Single Electron Transfer (SET) device.

Basic understanding of excitons in semiconductors and their consequence on optical properties of the material

Unit III **(5 Hours)**

Synthesis of Nanomaterials (Qualitative)

Top-down and Bottom-up approach, Ball milling, Spin Coating

Vacuum deposition: Physical vapor deposition (PVD): Thermal evaporation, Sputtering, Chemical vapor deposition (CVD). Preparation of colloidal solutions of Metals, Metal Oxide nanoparticles

Unit IV **(4 Hours)**

Applications (Qualitative)

Micro Electromechanical Systems (MEMS), Nanoelectromehanical Systems (NEMS). Applications of nanomaterials as probes in medical diagnostics and targeted drug delivery, sunscreen, lotions, and paints and other examples to give broader perspective of applications of nanomaterials.

PRACTICAL COMPONENT: NANOSCIENCE
(Hours: 60)

At least 06 experiments from the following:

1. Synthesis of metal (e.g. Ag) nanoparticles by chemical route and study its optical absorption properties.
2. Synthesis of semiconductor (CdS/ZnO/TiO_2/Fe_2O_3 etc) nanoparticles and study its Optical Absorption properties as a function of ageing time.
3. Surface Plasmon study of metal nanoparticles as a function of size by UV-Visible spectrophotometer.
4. Analysis of XRD pattern of given nanomaterial and estimate lattice parameters and particle size.
5. To study the effect of the size nanoparticles on its color.
6. To prepare composite of CNTs with other materials and study their optical absorption/Transmission properties.
7. Growth of metallic thin films using thermal evaporation technique.
8. Prepare a ceramic disc of a given compound and study its I-V characteristics, measure its dielectric constant or any other property.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study its transmittance spectra in UV-Visible region.
10. Prepare thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN junction diode by diffusing Al over the surface of N-type Si/Ge and study its V-I characteristic.
12. Fabricate thin films (polymer, metal oxide) using electro-deposition
13. To study variation of resistivity or sheet resistance with temperature of the fabricated thin films using four probe method.

REFERENCES

Essential Readings for the Theory Component

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt. Ltd..
2. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company)
3. K. K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Introduction to Nanoelectronics, V. V. Mitin, V.A. Kochelap and M.A. Stroscio,2011, Cambridge University Press.
5. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).
6. Introductory Nanoscience by Masaru Kuno, (2012) Garland science Taylor and Francis Group

7. Electronic transport in mesoscopic systems by Supriyo Datta (1997) Cambridge University Press.
8. Fundamentals of molecular spectroscopy by C. N. Banwell and E. M. McCASH, 4^{th} edition, McGrawHill.

Additional Readings for the Theory Component

1. Quantum Transport in semiconductor nanostructures by Carla Beenakker and HenK Van Houten (1991) (available at arXiv: cond-mat/0412664) Open Source
2. Sara Cronewett Ph.D. thesis (2001) for extra reading (Available as Arxiv).
3. Solid State Physics by J. R. Hall and H. E. Hall, 2^{nd} edition (2014) Wiley

References for the Practical Component

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1^{st} edition (2003) Wiley India Pvt. Ltd..
2. S. K. Kulkarni, Nanotechnology: Principles & Practices 2^{nd} edition (2011) (Capital Publishing Company)
3. K. K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 16
NUCLEAR AND PARTICLE DETECTORS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Nuclear and Particle Detectors DSE 16	4	3	1	0	

COURSE OBJECTIVES

This course introduces students to the principles and applications of detectors used in various fields of Physics, including Particle physics, Astrophysics, Nuclear physics and Medical physics. The course covers the theory of detectors, their design and operation including electronic readout systems and signal processing.

LEARNING OUTCOMES

- To understand the different types of detectors used in physics experiments.
- To learn the design construction and operation of detectors.
- To acquire knowledge of electronic readout systems and signal processing.
- To apply the principles of detectors in solving problems in various fields of physics.

SYLLABUS OF DSE 16
THEORY COMPONENT
(Hours: 45)

Unit I **(11 Hours)**

Interaction of Nuclear Radiation with matter
Interaction of radiation for light ions (electrons) and heavy charge particles, neutron and photons with matter. Energy loss due to ionization (Bethe-Block formula), for both light and heavy -ions, Cerenkov radiation. Gamma ray interaction with matter. Neutron interaction with matter.
Introduction to detectors
Definition of detectors, various types of detectors and their classification. Basic principle of detector operation and its modes of operation, pulse height spectra, various detector performance parameters: response time, energy resolution, fano factor, efficiency: intrinsic and extrinsic, dead time.

Unit II **(18 Hours)**

Gas detectors: Detector gases, gas detector characteristics, Different types of detectors: gas filled ionization detectors, proportional counters, multi wire proportional counters (MWPC), Geiger Mueller (GM) counters and Avalanche counters, gaseous multiplication detector.
Scintillation detectors: general characteristics, organic scintillators, inorganics crystals, intrinsic detection efficiency for various radiations. Photomultipliers: basic construction and operation, time response and resolution, noise, gain stability. Scintillation counter operation.
Semiconductor detectors:
Doped semiconductors, np semiconductor junction, depletion depth, detector characteristics of semiconductors. Types of semiconductor detectors with their principle of working: silicon diode detectors, Silicon strip detectors, silicon drift detectors, avalanche photodiodes, germanium detectors, other semiconductor materials.
Neutron detectors: slow neutron detectors: BF3 proportional counter, Boron Loaded scintillators, slow neutron detectors with Lithium. Fast neutron detectors

Unit III **(10 Hours)**

Electronics, signal processing and techniques for data acquisition and analysis
Basic idea of analog and digital signal processing, noise and its types. Instrumentation standards for Nuclear Instruments: NIM, ECL. TTL standards.
Electronics for energy spectroscopy: detector bias supply, preamplifiers, amplifiers, pulse amplitude discriminators, Single channel analyser, Scalers Counters and Timers.
Electronics for Timing with detectors: Timing Filter Amplifier (TFA), Timing single channel Analyser (TSCA), Gate and Delay Generator (GDG).
Electronics for position determination.
Data acquisition system: VME and Digital pulse processing system.

Unit IV **(6 Hours)**

Application of detectors
Application of detectors (two examples each): for nuclear and particle physics experiments, for astrophysics, for medical physics and imaging.

REFERENCES

1. Radiation detection and measurement: G F Knoll, John Wiley & Sons, 2010.
2. Techniques for Nuclear and Particle Physics experiments by WR Leo, Springer, 1994.
3. Nuclear Radiation Detectors: S. S. Kapoor, V. S. Ramamurthy. 1st Edition, John Wiley & Sons.
4. Physics and Engineering of Radiation Detection: S N Ahmed, Academic Press Elsevier, 2007.
5. Semiconductor Detectors: New Developments, E. Gatti and P. Rehak. 2002. Springer.
6. Principles of radiation interaction in matter and detection: C. Leroy and P.G. Rancoita. 3rd ed. World scientific.
7. Radiation Detection for Nuclear Physics Methods and industrial applications: D. Jenkins.

8. Advanced Nuclear Radiation Detectors Materials, processing, properties and applications: Ashok K Batra. IOP Publishing.
9. Measurement and Detection of Radiation: Nicholas Tsoulfanidis Et Al, Fourth Edition, T and F CRC.
10. Principles of nuclear radiation detection: Geoffrey G. Eichholz, John W, Poston. CRC group of publishers.
11. Introduction to Nuclear Radiation Detectors: 2 (Laboratory Instrumentation and Techniques) P. Ouseph, Springer.

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 11
RESEARCH METHODOLOGY

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Research Methodology DSE 11	4	3	0	1	Basic ICT related skills

COURSE OBJECTIVES

This course has been designed to explore the basic dimensions of research and to impart quantitative and qualitative knowledge for conducting meaningful research. Starting from the philosophy of research, through awareness about the publication ethics and misconducts, this course covers all the methodological and conceptual issues required for a successful conduct of research. It gives an overview of research techniques, data management and analysis, and commonly used statistical methods in physical sciences.

LEARNING OUTCOMES

After successful completion of this course, students will be trained in the following.

- Skills to review literature and frame research problem.
- Comprehend the relevance of the tools for data collection and analysis.
- Writing a scientific report/research proposal.
- Software tools for research in physical sciences.
- Research integrity and publication ethics.
- Importance of intellectual property rights.
- Role of funding agencies in research.

SYLLABUS OF DSE 11
THEORY COMPONENTS
(Hours: 45)

Unit I **(6 Hours)**

Introduction to research methodology
Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey

(open-source and paid tools for keeping track of the literature)

Unit II **(15 Hours)**

Data collection, analysis and interpretation

Methods of data collection: survey, interview, observation, experimentation and case study; Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation).

Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of multiple linear regression analysis and theory of attributes).

Curve fitting using linear and nonlinear regression (parameter space, gradient search method and Marquardt method).

Role of simulation, calibration methods, error analysis, and background handling in experimental design.

Unit III **(7 Hours)**

Journals, Database and Research Metrics

Journals: Free, open source and paid journals, concept of peer reviewed journals, predatory and fake journals.

Databases: Indexing databases; citation databases (Web of science, Scopus); experimental physics databases (astrophysics (ADS, NED, SIMBAD, VizieR), biophysics (PubMed), particle physics (INSPIRE, CDS), condensed matter physics (X-ray database))

Research Metrics: Journal impact factor, SNIP, SJR, IPP, cite score; metrics (h-index, g index, i10 index, altmetrics), variations in research metrics across various disciplines, other limitations of the research metrics and impact factors

Unit IV **(8 Hours)**

Scientific Conduct and Publication Ethics

Current understanding of ethics; intellectual honesty and research integrity; communicating errors (erratum, correction and withdrawal); records and logs (maintaining records of samples, raw data, experimental protocols, observation logs, analysis calculations, and codes); scientific publication misconducts: plagiarism (concept, importance, methods and ways to detect and avoid plagiarism) and redundant publications (salami slicing, duplicate and overlapping publications, selective reporting and misrepresentation of data); environmental and other clearances (waste management, disposal of hazardous waste).

COPE guidelines on best practices in publication ethics

Unit V **(5 Hours)**

Scientific Writing and Software Tools

Writing a research paper and report: introduction, motivation, scientific problem, its methodology, any experimental set up, data analysis, discussion of results, conclusions

Referencing formats (APA, MLA) and bibliography management

Graphical software (open source, magic plot, gnu plot, origin); presentation tools (beamer)

Unit VI **(4 Hours)**

Intellectual Property Right and Research Funding
Basic concepts and types of intellectual property (patent, copyright and trademark)
Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

<u>PRACTICAL COMPONENT: RESEARCH METHODOLOGY</u>

(Hours: 30)

Students should perform at least 6 experiments from the following list, such that all the units mentioned below are covered.

Unit 1:

1. Identify a research problem, write its brief summary and make a corresponding flow chart
2. Identify a survey-based research problem in physics and create a questionnaire to collect data to perform meaningful research.
3. Write a literature review for a research problem.
4. Create a list of research topics (at least three) and read at least one research paper in each topic.

Unit 2:

1. Attend a research seminar and write a brief summary in 1000 words. Check the extent of plagiarism in this summary by using on-line plagiarism detection tools
2. Read a research paper based on the use of statistics in experimental physics and summarise its importance.
3. Collect publicly available experimental physics data. Identify the independent, dependent and control variables. Fit at least two mathematical models that can describe the data and compare their statistical significance.

Unit 3:

1. Review any three research papers.
    a. List the major strengths and weakness of all of them.
    b. For any one of these, create a referee report assuming you are a reviewer of the paper. Also draft a response to the referee's report assuming you are the author.
2. Review any research paper. Rewrite it as if the work has been done by you for the first time. Use two different referencing and bibliography styles

Unit 4:

1. Take data from any publicly available experimental physics database. Use Microsoft Office tools (such as chart/bar diagrams, equation editor etc. in Word, PowerPoint or Excel) to present, plot and infer relevant information from the data.
2. Write a scientific synopsis of a research paper using LaTeX.
3. Create a presentation using LaTeX and Beamer on any research topic
4. Select a funding agency and any two schemes or fellowships offered by them.

Make a report (using LaTeX) describing the objectives, areas of research support and various components of grants offered by them.

REFERENCES

Essential Readings

1) Management Research Methodology, K. N. Krishnaswamy, A. I. Sivakumar, M. Mathirajan, 2006, Pearson Education, New Delhi.
2) Research Methodology, Methods and Techniques, C. R. Kothari, 2nd edition, 2008, New Age International Publication.
3) Research Methodology, A step by step guide for beginners, R. Kumar, 6th edition, 2009, Pearson Education
4) Data reduction and error analysis for the physical sciences, P. R. Bevington and D. K. Robinson, 3rd edition, McGraw-Hill
5) Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, C. J. Holland, 2007, Entrepreneur Press

Additional Readings

1) Research Methods, R. Ahuja, 2001, Rawat Publications, New Delhi.
2) Research design: Qualitative, quantitative, and mixed methods approaches, J. W. Creswell, and J. D. Creswell, 2017, Sage Publications.
3) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, A. R. Miller and
M. H. Davis, 2000, West Group Publishers

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 17 SEMICONDUCTOR DEVICES - FABRICATION AND APPLICATIONS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Semiconductor Devices - Fabrication and Applications DSE 17	4	2	0	2	

COURSE OBJECTIVES

- This course provides a review of basics of semiconductors such as energy bands, doping, defects etc. and introduces students to various semiconductor and memory devices.
- Thin film growth techniques and processes including various vacuum pumps, sputtering, evaporation, oxidation and VLSI processing are described in detail.
- By the end of the syllabus, students will have an understanding of MEMS based transducers.

LEARNING OUTCOMES

At the end of this course, students will be able to achieve the following learning outcomes:

- Learn to distinguish between single crystal, polycrystalline and amorphous materials based on their structural morphology and learn about the growth of single crystals of silicon, using Czochralski technique, on which a present day electronics and IT revolution is based. Students will understand about the various techniques of thin film growth and processes.
- Appreciate the various VLSI fabrication technologies and learn to design the basic fabrication process of R, C, P- N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology.
- Gain basic knowledge on overview of MEMS (MicroElectro-Mechanical System) and MEMS based transducers.

SYLLABUS OF DSE 17
THEORY COMPONENT
(Hours: 30)

Unit I **(9 Hours)**

Introduction: Review of energy bands in materials. Metal, Semiconductor and Insulator. Doping in Semiconductors, Defects: Point, Line, Schottky and Frenkel. Single Crystal, Polycrystalline and Amorphous Materials. Czochralski technique for Silicon Single Crystal Growth. Silicon Wafer Slicing and Polishing.

Vacuum Pumps: Primary Pump (Mechanical) and Secondary Pumps (Diffusion, Turbomolecular, Cryopump, Sputter - Ion)– basic working principle, Throughput and Characteristics in reference to Pump Selection. Vacuum Gauges (Pirani and Penning).

Unit II **(10 Hours)**

Thin Film Growth Techniques and Processes: Sputtering, Evaporation (Thermal, electronBeam), Pulse Laser Deposition (PLD), Chemical Vapor Deposition (CVD). Epitaxial Growth.
Thermal Oxidation Process (Dry and Wet) Passivation. Metallization. Diffusion.

Unit III **(7 Hours)**

VLSI Processing: Clean Room Classification, Line width, Photolithography: Resolution and Process, Positive and Negative Shadow Masks, Photoresist, Step Coverage, Developer. Electron Beam Lithography. Etching: Wet Etching. Dry etching (RIE and DRIE). Basic Fabrication Process of R, C, P-N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology. Wafer Bonding, Wafer Cutting, Wire bonding and Packaging issues (Qualitative idea).

Unit IV **(4 Hours)**

Micro Electro-Mechanical System (MEMS): Introduction to MEMS, Materials selection for MEMS Devices, Selection of Etchants, Surface and Bulk Micromachining, Sacrificial Subtractive Processes, Additive Processes, Cantilever, Membranes. General Idea MEMS based Pressure, Force, and Capacitance Transducers.

PRACTICAL COMPONENT: SEMICONDUCTOR DEVICES - FABRICATION AND APPLICATIONS
(Hours: 60)

At least 06 experiments from the following:

1. Fabrication of thin films via dip-coating technique, deposition of metal contacts through thermal evaporation and investigation of their current–voltage (I–V) characteristics.
2. Fabrication of thin films via spin-coating technique, deposition of metal contacts through thermal evaporation and investigation of their current–voltage (I–V) characteristics
3. Fabrication of p-n junction using either p or n type substrate along with appropriate semiconducting layer and study its current-voltage (I-V) Characteristics.
4. Generation of vacuum in small tubes (varying volumes) using a mechanical rotary pump and measurement of pressure using vacuum gauges.
5. Selective etching of Different Metallic thin films using suitable etchants of different concentrations.
6. Wet chemical etching of Si for Micro-Electro-Mechanical Systems (MEMS) applications using different concentrations of etchant.
7. Calibrate semiconductor type temperature sensor (AD590, LM 35, LM 75).

8. To measure the resistivity of a germanium (Ge) semiconductor crystal with temperature (up to 150 ºC) by four-probe method.
9. Capacitance measurements of ceramics using LCR meter.
10. Capacitance measurements of dielectric thin film capacitor using LCR meter

REFERENCES

Essential Readings for the Theory Component

1. Physics of Semiconductor Devices, S. M. Sze. Wiley-Interscience.
2. Fundamentals of Semiconductor Fabrication, S.M. Sze and G. S. May, John-Wiley and Sons, Inc.
3. Introduction to Semiconductor materials and Devices, M. S. Tyagi, John Wiley & Sons VLSI Fabrication Principles (Si and GaAs), S. K. Gandhi, John Wiley & Sons, Inc.

Additional Readings for the Theory Component

Handbook of Thin Film Technology, Leon I. Maissel and Reinhard Glang.

References for the Practical Component

1. The science and Engineering of Microelectronics Fabrication, Stephen A. Champbell, 2010, Oxford University Press.
2. Introduction to Semiconductor Devices, Kelvin F.

Semester-VIII

B.Sc. (Honours) Physics

ISCIPLINE SPECIFIC C ORE COURSE – DSC 20: ADVANCED STATISTICAL MECHANICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Advanced Statistical Mechanics DSE 19	4	3	1	0	

COURSE OBJECTIVES

- To introduce the fundamental principles and mathematical framework of statistical mechanics.
- To understand the concept of ensembles (microcanonical, canonical, and grand canonical) and their application to physical systems.
- To introduce quantum statistical concepts such as the density matrix and its applications.
- To introduce basic concepts of interacting system with the Ising model

This course provides a strong foundation for advanced study in theoretical and applied physics, and prepares students for research or technical roles in fields involving thermodynamic systems, statistical modelling and complex systems.

LEARNING OUTCOMES

Upon successful completion of this course, students will be able to:

- Understand fundamental concepts and principles of statistical mechanics including macrostates, microstates, and phase space, and their significance in describing physical systems.
- Formulate the microcanonical ensemble and apply it to model systems such as classical and quantum harmonic oscillators and ideal gases.
- Explain the grand canonical ensemble, including equilibrium with a particle-energy reservoir.
- Establish the relationship between canonical and grand canonical partition functions and use them to evaluate thermodynamic properties of systems with variable particle numbers.
- Describe the basic principles of quantum statistical mechanics including the concept of quantum ensembles and density matrix
- Describe basic principles of statistical mechanics of interacting systems with the help of Ising model

SYLLABUS OF DSE 19
THEORY COMPONENT
(Hours: 45)

Unit I **(8 hours)**

Review of Microcanonical and Canonical Ensembles
Macrostates, microstates, phase space, microcanonical ensemble (no derivation), partition function and its use in finding various thermodynamic quantities (no derivation). Examples of systems with finite and infinite energy levels using microcanonical and canonical ensemble approaches.

Unit II **(12 hours)**

Grand Canonical Ensemble
Equilibrium between a system and a particle-energy reservoir, a system in grand canonical ensemble, physical significance of various statistical quantities, density and energy fluctuations in grand canonical ensemble: correspondence with other ensembles, relation between canonical partition function and grand canonical partition function.

Unit III **(12 Lectures)**

Quantum Mechanical Ensembles
Basic idea of quantum-mechanical ensemble theory. Density matrix of microcanonical, canonical and grand canonical ensembles, Particle in a box and quantum harmonic oscillator.

Unit IV **(13 Lectures)**

Interacting Systems
Introduction to the Ising model. Exact solution of Ising model in one dimension. Mean field approximation.

REFERENCES

Essential Readings

1. Statistical Mechanics - R. K. Pathria & Paul D. Beale, 4th Edition, (Academic Press,2021)
2. Introduction to Statistical Physics, Kerson Huang, 2nd Edition, (Taylor and Francis 2009)
3. Statistical Physics of Particles, Mehran Kardar (Cambridge University Press, 2007)
4. Statistical and Thermal Physics: An Introduction, Michael J R Hoch, 2nd Edition (CRC Press, 2021)

Additional Readings

1. Statistical Mechanics An advanced course with problems and solutions R. Kubo, First Edition (Elsevier, 2014)
2. Thermodynamics and Statistical Mechanics, Greiner, Neise and Stocker, Springer 1995.
3. Fundamentals of Statistical and Thermal Physics, F. Reif, McGraw-Hill, Inc., 1967
4. Statistical and Thermal Physics: With Computer Applications, Harvey Gould and Jan Tobochnik

ADVISORY

The course, Advanced Statistical Mechanics, is essential for several courses offered in the one-year M.Sc. program and is also included in the syllabi of various competitive examinations, including CSIR-NET, JEST, and GATE.

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 18: ADVANCED QUANTUM MECHANICS - II

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Advanced Quantum Mechanics-II DSE 18	4	3	1	0	Quantum Mechanics (DSC 14), and Advanced Quantum Mechanics-I (DSE 13)

COURSE OBJECTIVES

This course aims to:

- Introduce and develop approximation methods for solving quantum systems where exact solutions are not possible, including both time-independent and time-dependent approaches.
- Strengthen understanding of the interaction picture and its role in quantum dynamics.
- Equip students with the tools of scattering theory, including formal techniques like the Lippmann–Schwinger equation, Green's functions, and the Born approximation.
- Provide a conceptual and mathematical foundation for advanced topics in quantum physics such as quantum field theory, quantum optics, and condensed matter physics.

LEARNING OUTCOMES

At the end of this course, students will be able to

- Apply key approximation methods including time-independent perturbation theory, and the variational method to compute approximate energy levels and wavefunctions in stationary quantum systems.
- Analyze quantum systems under time-dependent perturbations using the interaction picture, derive transition probabilities, and apply Fermi's Golden Rule to systems with a continuum of final states.
- Formulate and solve quantum scattering problems using ket formalism, Lippmann–Schwinger equations, and the Born approximation.
- Perform partial wave analysis and interpret scattering processes through phase shifts, S-matrix properties, and the optical theorem.

SYLLABUS OF DSE 18
THEORY COMPONENT
(Hours: 45)

Unit I **(14 Hours)**

Approximation Methods for Stationary Systems
Time-independent perturbation theory up to second order perturbation for non- degenerate case with applications to perturbed potential wells, linear harmonic oscillator with perturbed force constant ($k \rightarrow (1+\varepsilon)k$), charged harmonic oscillator in a weak electric field. First order perturbation for anharmonic oscillator with cubic and quartic terms.
Degenerate systems with application to spin-orbit coupling and fine structure of hydrogenic atom, Zeeman effect (weak and strong field).
Variational method and its applications to ground state of simple harmonic oscillator and Helium atom, electron interaction energy and extension of variational method to excited states.

Unit II **(14 Hours)**

Approximation Methods for time-dependent perturbations
Interaction picture. Time-dependent perturbation theory (up to first order perturbation). Transition probabilities, transition to a continuum of final states, Fermi's Golden Rule. Application to constant and harmonic perturbations. Sudden and adiabatic approximations

Unit III **(10 Hours)**

Scattering: Wave packet description of scattering, scattering amplitude, differential and total cross section. Lippmann-Schwinger Equations, Formal treatment of scattering by Green's function method. Born approximation and applications to central potentials. Definition and properties of S-Matrix.

Unit IV **(7 Hours)**

Partial wave analysis: Asymptotic behaviour of partial waves, Phase shifts and angular momentum decomposition, Optical theorem and conservation of probability.

REFERENCES

Essential Readings

1. *Introduction to Quantum Mechanics*, D.J. Griffith, Pearson Education (2005).
2. *Modern Quantum Mechanics*, J. J. Sakurai and Jim Napolitano, Cambridge University Press (2021).
3. *Quantum Mechanics,* Eugene Merzbacher, John Wiley and Sons, Inc (2004).
4. *Quantum Mechanics: Theory and Applications*, Ajoy Ghatak and S. Lokanathan, Laxmi Publications (2019).
5. *Quantum Mechanics,* B. H. Bransden and C. J. Joachain, Prentice Hall (2000).

Additional Readings

11. *Principles of Quantum Mechanics*, R. Shankar, Springer (2008).

12. *Introduction to Quantum Mechanics*, Volume-I and II, C. Cohen-Tannoudji, Bernard Diu, and Franck Laloë, Wiley-VCH (2020).
13. *Introduction to Quantum Mechanics*, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications (1966).
14. *Quantum Mechanics*, Leonard I. Schiff, Tata McGraw Hill (2010).
15. *Quantum Mechanics*, Walter Greiner, Springer (2001).
16. *Quantum Mechanics*, Albert Messiah, Dover Publications Inc. (2014)
17. *Scattering Theory of Waves and Particles*, R. G. Newton, Springer-Verlag Berlin and Heidelberg GmbH & Co. (2014

ADVISORY

The course, Advanced Quantum Mechanics-II, is essential for several courses offered in the one-year M.Sc. program and is also included in the syllabi of various competitive examinations, including CSIR-NET, JEST, and GATE.

Colleges are advised to offer this as a Discipline Specific Elective (DSE). Students who intend to pursue postgraduate studies or appear for competitive exams are strongly encouraged to choose this course as a DSE.

DISCIPLINE SPECIFIC ELECTIVE – DSE 19 : ELECTRODYNAMICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Electrodynamics DSE 20	4	3	1	0	Vector calculus, Maxwell's equations, and basic Special Relativity

COURSE OBJECTIVES

This course provides a rigorous understanding of the behavior of charges and electromagnetic fields, motion in fields, and the fundamentals of radiation. Students will gain both theoretical insight and computational tools needed in advanced physics.

LEARNING OUTCOMES

After completing this course, students will be able to:

- Apply Maxwell's equations in relativistic contexts.
- Analyze the motion of charged particles in different electromagnetic field configurations.
- Understand and compute radiation fields from various charge-current distributions.
- Use covariant and Lagrangian formulations to express electrodynamics compactly.
- Solve applied problems related to electromagnetic radiation and antenna theory.

SYLLABUS OF DSE 20
THEORY COMPONENT
(Hours: 45)

Unit I **(15 Hours)**

Review of Maxwell's equations, scalar and vector potentials, gauge transformations, Coulomb and Lorentz gauges. Lorentz transformations in 4-vectors notation. Transformation of electric and magnetic fields.
EM field tensor: Construction and interpretation of $F^{\mu\nu}$, Covariance form of Maxwell's equations. Lorentz invariants $E^2 - B^2$ and $\vec{E}.\vec{B}$.

Unit II **(8 Hours)**

Lorentz force in relativistic form. Charged particle trajectories in static electric and magnetic fields. Crossed **E** and **B** fields, guiding center approximation: Velocity and curvature drifts.

Unit III **(14 Hours)**

Green's function for wave equation, retarded potentials using Green's function. Radiation from oscillating charges, radiation zones. Multipole expansion: dipole and quadrupole. Lienard - Wiechert potentials, Lienard's and Larmor's formulas. Angular distribution of radiation. Centre-fed linear antennas.

Unit IV **(8 Hours)**

Lagrangian for free relativistic particles. Systems with infinite degrees of freedom: Classical fields. Lagrangian for charged particles in EM fields and free EM fields. Energy-momentum tensor and conservation laws.

REFERENCES

Essential Readings

1. D.J. Griffiths and D.F. Schroeter, Introduction to Electrodynamics, 4th Edition, Cambridge University Press, 2017.
2. J.D. Jackson, Classical Electrodynamics, 3rd Edition, Wiley, 1998.
3. L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields, Course of Theoretical Physics Vol. 2, 4th Edition, Butterworth-Heinemann (Pergamon), 1975.
4. P. Lorrain and D.R. Corson, Electromagnetic Fields and Waves, 3rd Edition, W.H. Freeman and Company, 1988.
5. C.A. Brau, Modern Problems in Classical Electrodynamics, Oxford University Press, 2004.

Additional Readings

1. M. Schwartz, Principles of Electrodynamics, Dover Publications, 1987.
2. Julian Schwinger, L.L. DeRaad Jr., K.A. Milton, W.-Y. Tsai, Classical Electrodynamics, Westview Press, 1998.
3. L.D. Landau, E.M. Lifshitz, and L.P. Pitaevskii, Electrodynamics of Continuous Media, 2nd Edition, Course of Theoretical Physics Vol. 8, Butterworth-Heinemann, 1984.
4. J.R. Reitz, F.J. Milford, R.W. Christy, Foundations of Electromagnetic Theory, 4th Edition, Addison-Wesley, 1992.
5. A. Zangwill, Modern Electrodynamics, Cambridge University Press, 2013.
6. Jerrold Franklin, Classical Electromagnetism, Addison-Wesley, 2005.
7. J. Panofsky and M. Phillips, Classical Electricity and Magnetism, 2nd Edition, Dover Publications, 2005.
8. Mark A. Heald and Jerry B. Marion, Classical Electromagnetic Radiation, 3rd Edition, Dover Publications, 2012.

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 20: DIGITAL SIGNAL PROCESSING

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Digital Signal Processing DSE 20	4	2	0	2	

COURSE OBJECTIVES

- This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals.
- This paper also highlights the concept of filters and realization of Digital Filters.
- At the end of the syllabus, students will develop an understanding of Discrete and fast Fourier Transform.

LEARNING OUTCOMES

At the end of this course, students will be able to develop following learning outcomes:

- Students will learn basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear time-invariant (LTI) systems.
- The student will be in position to understand use of different transforms and analyze the discrete time signals and systems. They will learn to analyze a digital system using z-transforms and discrete time Fourier transforms, region of convergence concepts, their properties and perform simple transform calculations.
- The student will realize the use of LTI filters for filtering different real world signals. The concept of transfer Function and difference-Equation System will be introduced. Also, they will learn to solve Difference Equations.
- Students will develop an ability to analyze DSP systems like linear-phase, FIR, IIR, All-pass, averaging and notch Filter etc.
- Students will be able to understand the discrete Fourier transform (DFT) and realize its implementation using FFT techniques.
- Students will be able to learn the realization of digital filters, their structures, along with their advantages and disadvantages. They will be able to design and understand different types of digital filters such as finite & infinite impulse response filters for various applications.

SYLLABUS OF DSE 20
THEORY COMPONENT
(Hours: 30)

Unit I **(7 Hours)**

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical and Analytical Method, Properties of Convolution (General Idea); Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response.

Unit II **(9 Hours)**

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z- Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of-Convergence; Differentiation in the z-Domain; Power Series Expansion Method (General Idea). Transfer Function and Difference-Equation System.

Unit III **(10 Hours)**

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters (only qualitative treatment).
Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation (general idea), Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution).

Unit IV **(4 Hours)**

Realization of Digital Filters: FIR Filter structures; Direct-Form; Cascade-Form
Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR Filters.

PRACTICAL COMPONENT: DIGITAL SIGNAL PROCESSING
(Hours: 60)

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors and application to the specific experiments done in the lab.

At least 06 experiments from the following using Scilab/Matlab/Python.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence *u(n)*, (c) ramp sequence *r(n)*, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \leq n \leq 50$.
2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for N = 5

$$\mathrm{x(n)} = \mathrm{rect}\left(\frac{\mathrm{n}}{2\mathrm{N}}\right) = \prod\left(\frac{\mathrm{n}}{2\mathrm{N}}\right) = \begin{cases} 1 & -\mathrm{N} \leq \mathrm{n} \leq \mathrm{N} \\ 0 & \text{otherwise} \end{cases}$$

3. An LTI system is specified by the difference equation: y(n)=0.8y(n-1)+x(n)
   (a) Determine $\mathrm{H}(\mathrm{e}^{\mathrm{iw}})$
   (b) Calculate and plot the steady state response y(n) to $\mathrm{x(n)} = \cos\cos(0.5\pi\mathrm{n})\,\mathrm{u(n)}$
4. Given a casual system y(n)=0.9y(n-1)+x(n)
   (a) Find H(z) and sketch its pole-zero plot
   (b) Plot the frequency response $|H(e^{jw})|$ and $\angle H(e^{jw})$
5. Design a digital filter to eliminate the lower frequency sinusoid of *x(t)=sin7t+sin200t*. The sampling frequency is 500 Hz. Plot its pole zero diagram, magnitude response, input and output of the filter.
6. Let *x(n)* be a 4-point sequence:
   $x(n) = \{1,1,1,1\} = \begin{cases} 1 & 0 \leq n \leq 3 \\ 0 & otherwise \end{cases}$

   Compute the DTFT $X(e^{jw})$ and plot its magnitude
   (a) Compute and plot the 4 point DFT of *x(n)*
   (b) Compute and plot the 8 point DFT of *x(n)* (by appending 4 zeros)
   (c) Compute and plot the 16 point DFT of *x(n)* (by appending 12 zeros)
7. Let *x(n)* and *h(n)* be the two 4-point sequences,
   x(n)={1,2,2,1} *h(n)={1,-1,-1,1}*

   Write a program to compute their linear convolution using circular convolution.
8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specifications:

   Passband edge F_p=2 KHz
   Stopband edge F_s=5 KHz
   Passband attenuation A_p=2 dB
   Stopband attenuation A_s=42 dB
   Sampling frequency F_{sf}=20 KHz

10. The frequency response of a linear phase digital differentiator is given by

$$\mathrm{H_d}\left(\mathrm{e}^{\mathrm{jw}}\right) = \mathrm{jwe}^{-\mathrm{j}\tau\mathrm{w}} \quad |\mathrm{w}| \leq \pi$$

    Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response

REFERENCES

Essential Readings for the Theory Component

1. Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
2. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
3. Principles of Signal Processing and Linear Systems, B.P. Lathi, 2009, 1st Edn. Oxford University Press.
1. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
2. Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4th Edn., Prentice Hall.

Additional Readings for the Theory Component

1. Digital Signal Processing, A. Anand Kumar, 2nd Edition, 2016, PHI learning Private Limited.
2. Digital Signal Processing, Paulo S.R. Diniz, Eduardo A.B. da Silva, Sergio L. Netto, 2nd Edition, 2017, Cambridge University Press.

References for the Practical Component

1. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.
2. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
3. Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 21: GROUP THEORY AND ITS APPLICATIONS

Course Title and Code	Credits	Credit Distribution of the Course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Group Theory and Application DSE 21	4	3	1	0	Knowledge of Linear Algebra is recommended

COURSE OBJECTIVES

- To introduce students to the fundamental structures and operations of group theory.
- To develop the ability to construct and classify groups, subgroups, and their representations.
- To prepare students to apply group theoretical methods to problems in quantum mechanics, molecular physics, and crystallography.
- To provide a rigorous foundation in both finite and continuous groups relevant to advanced physics.

LEARNING OUTCOMES

After completing this course, students will be able to:

- Identify and classify groups, subgroups, and conjugacy classes.
- Understand and use homomorphisms, isomorphisms, and quotient structures.
- Construct and analyze matrix representations of groups.
- Apply character theory and the Great Orthogonality Theorem.
- Analyze symmetries in quantum systems using SU(2), SU(3), and SO(n) groups.
- Interpret and utilize point groups and space groups in solid-state and molecular systems.

SYLLABUS OF DSE 21
THEORY COMPONENT
(Hours: 45)

Unit I **(13 Hours)**

Basics of Group Theory
Symmetry and Groups, Properties of groups, Abelian and non-abelian groups. Cayley Table and Diagram. Concept of Subgroup, cyclic subgroups, center of a group. Cosets and Lagrange's Theorem. Direct Sum and Direct Product of Groups.
Homomorphism and Isomorphism of Groups. Kernel and Image of Homomorphism. Representations of Groups.

Unit II **(12 Hours)**

Finite Groups and Representations
Permutation Groups, Cayley's Theorem (Statement only). Normal subgroups, Quotient Groups and Simple groups. Conjugate Subgroups and conjugacy classes. Dihedral Groups. Classes, Unitary representations, Reducible and Irreducible representations of finite groups. Schur's Lemma. Great Orthogonality Theorem and Character Table. Dimensionality Theorem. Direct product of representation and representation of Direct Product Groups.

Unit III **(10 Hours)**

Continuous Groups
U (1) group, Lie Groups and Generators of Group. Lie Algebra and Jacobi Identity. Orthogonal Lie Groups. Rotation group in 2 and 3 dimensions: SO(2), SO(3) and their generators. Unitary Lie Groups: SU(2), SU(3) and their generators. Homomorphism of SU(2) and SO(3). Homogenous Lorentz Group.

Unit IV **(10 Hours)**

Applications in Physics
SU(2) and quantum spin: Irreducible representation of SU(2) and their relation to spin. Direct Product of representations and Addition of Angular momentum. Clebsch-Gordan Decomposition and Coefficients.
Crystal Symmetry: Point Groups and examples, Point group C_{4v} and its character table. Significance of character table in studying crystal properties.
Space Groups and examples, Space Group P4mm corresponding to the point group C_{4v}.

REFERENCES

Essential Readings

1. Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, Elsevier (2010).
2. Mathematical Methods for Physics and Engineering, K. F. Riley, M. P. Hobson, S. J. Bence, Cambridge University Press (2006).
3. Mathematical Physics with Applications, Problems and Solutions, V. Balakrishan, Ane Books (2017).

4. Group Theory and its Applications to Physical Problems, by Morton Hamermesh, Dover Publications (1989).
5. Introduction to Mathematical Physics: Methods & Concepts, Chun Wa Wong, Oxford University Press (2012).
6. Mathematical Methods for Physicists: A Concise Introduction, Tai L. Chow, Cambridge University Press (2000).
7. Groups, Representations and Physics, H. F. Jones, Taylor & Francis (1998).
8. Group Theory in Physics: An Introduction to Symmetry Principles, Group Representations, and Special Functions in Classical and Quantum Physics, Wu-Ki Tung, World Scientific Publishing Co. Pte. Ltd. (2003).
9. Group Theory in a Nutshell for Physicists, A. Zee, Princeton University Press (2016).

Additional Readings

1. Introduction to Mathematical Physics: Methods and Concepts, Chun Wa Wong, Oxford University Press (2012).
2. Group Theory: A Physicist's Survey, Pierre Ramond, Cambridge University Press (2010).
3. A Physicist's Introduction to Algebraic Structures: Vector Spaces, Groups, Topological Spaces and More, Palash B Pal, Cambridge University Press (2019).
4. Schaum's outline of Group Theory, B. Baumslag and B. Chandler, McGraw Hill Education (1968).
5. Contemporary Abstract Algebra, Joseph A Gallian, 9th ed, Brooks/Cole Cengage Learning (2017).
6. Group Theory in a Nutshell for Physicists, A. Zee, Princeton University Press (2016).
7. Group Theory in Physics: An Introduction with a Focus on Solid State Physics, Jörg Bünemann, Springer Nature (2024).
8. Group Theory in Physics: An Introduction, J. F. Cornwell, Academic Press (1997).
9. Classical groups for physicists, B.G. Wybourne, Wiley
10. Chemical Applications of Group Theory, F A Cotton, John Wiley and Sons (1990).
11. Lie Algebras in Particle Physics, H. Georgi, CRC Press (1999).
12. Group Theory in Physics: An Introduction with a Focus on Solid State Physics, Jörg Bünemann, Springer Nature (2024).

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE - DSE 22: NUCLEAR AND PARTICLE PHYSICS

Course Title and Code	Credits	Credit Distribution of the Course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Nuclear and Particle Physics DSE 22	4	3	1	0	

COURSE OBJECTIVE

The objective of the course is to impart the understanding of the sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application. The course will focus on the developments of problem-based skills.

LEARNING OUTCOMES

- To be able to understand the basic properties of nuclei: Nuclear charge and mass density, size, magnetic and electric moments
- To appreciate the formulations and contrasts between different nuclear models such as Liquid drop model, Fermi gas model and Shell Model and evidences in support.
- Familiarization with different types of nuclear reactions, Q- values, compound and direct reactions.
- To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter and neutron interaction with matter.
- To understand classification of fundamental forces based on their range, time-scale and mediator mass.
- To understand Scattering cross-sections of 2 to 2 processes and their inherent symmetries.
- Angular and energy distributions for three body decay process.
- Discrete symmetries of nature and associated conservation laws and Colour triplet

SYLLABUS OF DSE 22
THEORY COMPONENT
(Hours: 45)

Unit I **(15 Hours)**

General Properties of Nuclei and Nuclear Models: Constituents of nucleus and their Intrinsic properties. Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas). Single Particle Shell Model (Concept of mean field and spin orbit coupling), Estimation of Spin parity and electromagnetic moments for ground state configuration for even- even, even -odd and odd-odd nuclei. Basic concept of Collective Model and deformed shell model.

Unit II **(10 Hours)**

Nuclear Reactions: Types of Reactions, Units of related physical quantities, Conservation Laws, Kinematics of reactions, Q-value, Reaction rate, Reaction cross section, Concept of compound and direct reaction, Coulomb scattering (Rutherford scattering).

Unit III **(8 Hours)**

Interaction of Nuclear Radiation with matter: Interaction of radiation for light ions (electrons) and heavy charge particles, neutron and photons with matter. Energy loss due to ionization (Bethe-Block formula), for both light and heavy-ions, Cerenkov radiation. Gamma ray interaction with matter. Neutron interaction with matter.

Unit IV **(12 Hours)**

Particle Physics: Overview of Particle spectrum and their interactions in the Standard Model. Range, time-scale and relative strength of interactions. Interactions at a distance mediated by virtual particles (Exchange Force).
Requirement of High Energy Colliders to probe the constituents of nucleon, Linear and circular colliders, Inelastic collisions at Hadron colliders. Brief idea about Large Hadron Collider experiment and Indian ALICE and CMS and collaborations.
Kinematics for $2 \rightarrow 2$ scattering processes and Crossing symmetries of scattering amplitudes. Angular and energy distributions of decaying particles in $1 \rightarrow 3$ decay processes (muon decay / beta decay).
Lepton and Baryon quantum numbers. Isospin, Strangeness and Hypercharge. Gell-Mann-Nishijima formula. Parity and Charge conjugation of a particle state. Time Reversal and General CPT theorem.
Valence quark model of Murray Gell-Mann and Yuval Ne'eman, current and constituent masses of quarks, flavor symmetry Isospin triplets, Baryon octet and decuplet, Meson octet. Antisymmetric Δ^{++} state and necessity for color quantum number. Evidence for color triplet quarks from $\mathbf{e^+e^-}$ annihilation experiment.

<u>**REFERENCES**</u>

Essential Readings

For Nuclear Physics

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2. Introductory Nuclear Physics by K S Krane, Wiley-India Publication, 2008.
3. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
4. Nuclear Physics: principles and applications by J Lilley, Wiley Publication, 2006.
5. Concepts of Nuclear Physics by B L Cohen, Tata McGraw Hill Publication, 1974.
6. Radiation detection and measurement, G F Knoll, John Wiley & Sons, 2010.

For Particle Physics

7. Modern Particle Physics by Mark Thompson, Cambridge University Press, 2013.
8. Particles and Nuclei: An Introduction to the Physical Concepts by Bogdan Povh, Klaus Rith, Christoph Scholz, Frank Zetsche, Werner Rodejohann, Springer-Verlag 2015.
9. An Introductory Course of Particle Physics, Palash B. Pal (CRC Press, 2015)
10. Introduction to High Energy Physics by D H Perkins, 4th edition, Cambridge University Press, 2000.
11. Introduction to elementary particles by D J Griffiths, Wiley, 2008.
12. Quarks & Leptons, F. Halzen and A. D. Martin (John Wiley, 1984)

References for Tutorials

13. Problems and Solutions in Nuclear and Particle Physics by Sergio Petreta, Springer, 2019.
14. Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
15. Schaum's Outline of College Physics, by E. Hecht, 11th edition, McGraw Hill, 2009.
16. <u>Problems and Solutions on Atomic, Nuclear and Particle Physics</u> by Yung-Kuo Lim, World Scientific, 2000.
17. Nuclear Physics "Problem-based Approach" Including MATLAB by Hari M. Aggarwal, PHI Learning Pvt. Ltd. (2016).

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE - DSE 23: PLASMA PHYSICS

Course Title and Code	Credits	Credit Distribution of the Course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Plasma Physics DSE 23	4	3	1	0	DSC 13 - Electromagnetic Theory (Sem. V) and DSC 8 - Thermal Physics (Sem. III) of this program or its equivalent.

COURSE OBJECTIVES

This course presents the characteristic plasma properties and theoretical approaches to plasma physics. It treats single charged-particle motion in electromagnetic fields, collisions, electrical conductivity and diffusion, and plasma waves. Applications to controlled thermonuclear fusion, plasma processing, and astrophysical plasmas will serve to illustrate when and where the various theories are applicable.

LEARNING OUTCOMES

At the end of the course, the students will be able to:

- define, using fundamental plasma parameters, under what conditions an ionised gas consisting of charged particles (electrons and ions) can be treated as a plasma.
- know various applications of plasma physics.
- determine the drift velocities of charged particles moving in electric and magnetic fields that are either uniform or vary slowly in space and time.
- distinguish the single particle approach, fluid approach to describe different plasma phenomena and formulate the conditions for a plasma to be in a state of perfect thermodynamic equilibrium.
- apply the conservation laws and Maxwell's equations to describe dynamical processes like wave propagation in a plasma.

SYLLABUS OF DSE 23
THEORY COMPONENT
(Hours: 45)

Unit I **(12 Hours)**

Introduction to plasma: Basics of gas dynamics, occurrence of plasma in nature, concept of temperature and density of plasma, Saha's equation, quasineutrality in plasma, collective behaviour, Debye shielding, Microscopic Properties (resistivity and conductivity).

Unit II **(8 Hours)**

Plasma applications and measurement: Gas discharge, industrial plasma, ionosphere plasma, solar plasma, plasma processing of materials, laser ablation, laser-driven fusion, magnetic fusion, plasma propulsion. Basics of Plasma production in laboratory and diagnostics

Unit III **(13 Hours)**

Particle confinement: Single particle motion in the presence of uniform and non-uniform electric and magnetic field, Grad-B drift, curvature drift, polarization drift, Magnetic mirrors and concept of earth magnetic mirror, Basic concept of controlled thermonuclear fusion.

Unit IV **(12 Hours)**

Fluid description of plasma: Set of fluid equations of plasmas, diamagnetic drift of plasma, plasma approximation, waves in cold plasmas, plasma oscillations, electron plasma wave, ion acoustic wave, electromagnetic wave in unmagnetized plasma.

REFERENCES

1. Introduction to Plasma Physics and Controlled Fusion by F. F. Chen (Third Edition 2016).
2. The Physics of Plasmas, by T. J. M. Boyd and J. J. Sanderson. Cambridge University Press, 2003.
3. Introduction to Plasma Physics, R.J. Goldston and P. H. Rutherford (IOP, 1995).
4. Fundamentals of Plasma Physics -J. A. Bittencourt, Springer, New York, NY (Third edition).
5. The physics of fluids and plasmas: an introduction for astrophysicists – Arnab Rai Choudhuri, Cambridge University Press (1998)
6. Principles of Plasma Physics, N.A. Krall and A.W. Trivelpiece, Mc Graw Hill (1973).
7. Principles of Plasma Discharges and Materials Processing (Second Edition, 2005) by Lieberman, Lichtenberg.

B.Sc. (Honours) Physics

DISCIPLINE SPECIFIC ELECTIVE COURSE - DSE 24: SENSORS AND DETECTORS

Course Title and Code	Credits	Credit Distribution of the Course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Sensors and Detectors DSE 24	4	3	0	1	DSC 13 - Electromagnetic Theory (Sem. V) and DSC 8 - Thermal Physics (Sem. III) of this program or its equivalent.

COURSE OBJECTIVES

To make students familiar with the constructions and working principle of different types of sensors and transducers. To make students aware about the measuring instruments and the methods of measurement and the use of different transducers.

LEARNING OUTCOMES

At the end of the course, a student will be able to:

- Use concepts in common methods for converting a physical parameter into an electrical quantity.
- Classify and explain with examples of transducers, including those for measurement of temperature, strain, motion, position and light.
- Choose proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc.
- Predict correctly the expected performance of various sensors.
- Locate different type of sensors used in real life applications and paraphrase their importance.
- Set up testing strategies to evaluate performance characteristics of different types of sensors and transducers and develop professional skills in acquiring and applying the knowledge outside the classroom through design of a real-life instrumentation system.

SYLLABUS OF DSE 24
THEORY COMPONENT
(Hours: 45)

Unit I **(13 Hours)**

Transducers, Classification of transducers on different basis, Types of transducers (Basic idea of Mechanical, resistive, capacitive, inductive, piezoelectric, optical and digital).
Sensor, Components of sensor, Direct and complex sensor (Basic idea)
Distinction between Sensor and Transducer, Characteristics of Transducers/Sensor: Static characteristics and static calibration (Calibration accuracy and component error), Dynamic characteristics.
Inductive sensor: Variable Inductance Sensors, Plunger type displacement sensor, Variable Gap Sensor, LVDT: Construction, working, output characteristics. Idea of RVDT (Qualitative).
Capacitive sensors: Variable distance-parallel plate type, variable area- parallel plate (serrated plate/teeth type), variable dielectric constant type; Sensitivity of capacitive sensors, Stretched diaphragm type

Unit II **(9 Hours)**

Magnetic Sensors: Magnetoresistive Sensors and Hall effect sensor (performance and characteristics).
Temperature sensor: RTD (construction, working and temperature coefficient), thermistor, categories of thermistor (PTC and NTC: material, shape, ranges, RT curve and accuracy specification), Thermo emf sensor (thermoelectricity generation, thermos-emf measurement, Thermocouples (construction, characteristics), and Pyroelectric sensors (pyroelectric effect and output voltage-temperature relationship).

Unit III **(13 Hours)**

Pressure sensors: Direct versus indirect pressure measurement, Different types of gauges and their working range, Mechanical gauges (McLeod Gauge), Thermal Conductivity Gauges (Thermocouple and Pirani gauges) and Ionization gauges (hot & cold cathode), advantages and limitations of various types of gauges, Gauge calibration (Static: Manometric method and dead-beat tester, dynamic calibration).
Radiation Sensors: Basic Characteristics (Concept of Work Function, Spectral Sensitivity, Spectral threshold, Quantum yield, time lag, linearity, Status and dynamic response), Types of Photodetectors: Photoemissive Cell, Photo Multiplier, Photo conductive Cell (LDR), Photovoltaic cells, photodiodes. Detection of Nuclear Radiation: Qualitative treatment of Geiger Muller counters and Scintillation detectors.

Unit IV **(10 Hours)**

Applications of Sensors and detectors: Basic principles of Remote sensing, Introduction to LiDAR (principles, applications and benefits), Types of LiDAR (air-borne and ground based) Applications of motion sensors in accelerometers and gyroscopes (qualitative analysis of working principle).
Biomedical Sensor: Electrochemical sensor (electrochemical cell, cell potential, three electrodes system, working principle).

PRACTICAL COMPONENT: SENSORS AND DETECTORS
(Hours: 30)

At least 5 experiments to be done from the list below:

1. Characteristics of LDR as a function of distance from light source.
2. Light characteristics of Photodiode.
3. Measurement of Strain using Strain Gauge.
4. To study the characteristics of a Linear Variable Differential Transformer (LVDT).
5. To study the characteristics of a Resistance Temperature Device (RTD).
6. To study the frequency response of a loudspeaker.
7. Determine characteristics of an Infrared (IR) emitter-receiver module.
8. Create vacuum in a small chamber using a mechanical (rotary) pump and/or secondary pump and measure the chamber pressure using a pressure gauge – Pirani and/or CC gauge.
9. Measurement of thermos-emf in thermopile and to calculate the Seebeck coefficient.
10. Study the pyroelectric effect and generation of induced voltage with temperature change.

REFERENCES

Essential Readings for the Theory Component

1. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
2. Introduction to Measurements and Instrumentation, A.K. Ghosh, PHI Learning Pvt. Ltd.
3. 3.Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
4. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata
5. McGraw Hill
6. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer
7. Electronic Instrumentation by H. S. Kalsi (Mc Graw Hill Publisher)
8. Sensors and Transducers, D Patranabis, PHI Learning Pvt. Ltd.
9. An Introduction to Sensors and Instrumentations, Sobnath Singh, Narosa
10. Handbook of Modern Sensors, Jacob Fraden, Springer
11. Handbook of Thion film Technology, Maissel and Glang, Tata McGraw Hill
12. Instrumentation, Measurement and Analysis, Nakra and Chaudhry, McGraw Hill

Additional Readings for the Theory Component

1. Radiation detection and measurement, G.F. Knoll, Wiley
2. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M.Sayer and A. Mansingh, PHI

References for the Practical Component

1. Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, Springer
2. Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino, M. A. Miller, McGraw

DEPARTMENT OF PHYSICS AND ASTROPHYSICS

Undergraduate Curriculum Framework 2022

- B.Sc. Physical Sciences with Physics as one of the Core Disciplines
- B.Sc. Physical Sciences with Physics & Electronics as Core Disciplines

FOR MAJOR IN PHYSICS

Semester-VII and VIII

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	Nuclear and Particle Physics	3	1	0	50
	Plasma Physics	3	1	0	53
	Sensors and Detectors	3	0	1	55
SBC	Interfacing with Arduino	0	0	2	58
	Weather Forecasting	1	0	1	60
	PCB Designing and Fabrication**	0	0	2	-

Note:

1. Here,
   DSC: Discipline Specific Core
   DSE: Discipline Specific Elective
   SBC: Skill-based Course
2. * Research Methodology is the same as notified as a DSE for Sem VI (DU Notification dated 16.5.2024).
3. ** Are SEC notified on 28.3.2023.
4. Students should ensure that they do not repeat a SEC course as SBC.
5. As it is NOT permissible to choose courses having similarity of the content to the tune of 30% or more, students should ensure that while opting DSEs.

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – DSC 7-1 : STATISTICAL MECHANICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Statistical Mechanics DSC 7-1	4	3	1	0	

COURSE OBJECTIVES

The course aims to:

- Introduce the fundamental concepts of statistical physics such as phase space, microstates, macrostates, and the basic idea of ensembles.
- Provide a thorough understanding of classical (Maxwell-Boltzmann) and quantum (Bose-Einstein and Fermi-Dirac) statistics.
- Develop skills to derive thermodynamic properties of ideal and degenerate gases using partition functions and distribution functions.
- Apply statistical methods to understand physical phenomena such as Bose-Einstein condensation, photon gas and negative temperature.
- Explore the qualitative concept of white dwarf stars and Chandrasekhar mass limit.

LEARNING OUTCOMES

By the end of the course, students will be able to:

- Explain the foundational concepts of phase space, macrostates, microstates, and the basic idea of ensembles.
- Apply the Maxwell-Boltzmann distribution law to calculate thermodynamic quantities of an ideal gas using the partition function.
- Apply the law of equipartition of energy to analyze specific heat capacities of gases and explain its limitations at low temperatures.

- Describe the Bose-Einstein distribution and apply it to systems like photon gas and a two-level system, including concepts like negative temperature and Bose-Einstein condensation.

- Apply the Fermi-Dirac distribution to calculate thermodynamic functions of degenerate fermion systems and describe qualitatively the physics of white dwarf stars and the Chandrasekhar mass limit.

SYLLABUS OF DSC 7
THEORY COMPONENT
(Hours: 45)

Unit I **(6 Hours)**

Introduction to Classical Statistics
Macrostates and Microstates, Phase Space, Entropy and Thermodynamic Probability

Unit II **(12 Hours)**

Maxwell-Boltzmann distribution
Partition function, thermodynamic functions of an ideal gas, Gibbs paradox, Sackur-Tetrode equation; law of equipartition of energy (with proof) – Applications to specific heat of gases and its limitations, thermodynamic functions of a two-level system, negative temperature.

Unit III **(15 Hours)**

Bose-Einstein Statistics
Bose-Einstein distribution law, thermodynamic functions of a strongly degenerate Bose gas (non-relativistic), Bose-Einstein condensation, properties of liquid He (qualitative description only), radiation as a photon gas and thermodynamic functions of photon gas; Derivation of Planck's law using B-E statistics.

Unit IV **(12 Hours)**

Fermi-Dirac Statistics
Fermi-Dirac distribution law, thermodynamic functions of a completely and strongly degenerate Fermions (non-relativistic), specific heat of metals, relativistic Fermi gas, White dwarf stars and Chandrasekhar mass limit (qualitative concepts only).

REFERENCES

Essential Readings

1. Statistical Mechanics - R. K. Pathria & Paul D. Beale, 4th Edition, (Academic Press,2021)
2. Introduction to Statistical Physics, Kerson Huang, 2nd Edition, (Taylor and Francis 2009)
3. Thermodynamics, Kinetic theory and Statistical thermodynamics, Sears and Salinger, PHI

4. Introductory Statistical Mechanics, R. Bowley and M. Sanchez, Oxford Univ. Press
5. Concepts in Thermal Physics, Blundell and Blundell, Oxford University Press
6. Problems and Solutions on Thermodynamics and Statistical Mechanics, Lim Yung-Kou, Sarat Book House
7. Statistical and Thermal Physics, Loknathan and Gambhir, PHI

Additional Readings

1. An Introduction to Statistical Physics, W. G. V. Rosser, Wiley
2. An Introduction to Thermal Physics, D. Schroeder, Pearson
3. Statistical Mechanics, G. Sanon, Narosa Publishers

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7-1 : ADVANCED MATHEMATICAL PHYSICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Advanced Mathematical Physics DSE 7-1	4	3	1	0	

COURSE OBJECTIVES

The course is intended

- To impart the basic concepts of cartesian tensors to have in-depth analysis of physical system.
- To grasp the foundational principles of group theory so that students can apply it in theoretical and experimental physics.

LEARNING OUTCOMES

After completing the course the students will be able to

- Learn basic properties of cartesian tensors with physical examples such as moment of inertia tensor, stress tensor, strain tensor etc.
- Learn elementary group theory: definition and properties of groups, subgroups, Homomorphism, Isomorphism and Normal groups.

SYLLABUS OF DSE 7-1
THEORY COMPONENT
(Hours: 45)

Unit I **(10 hours)**

Cartesian Tensors
Transformation of Co-ordinates and fundamentals of Tensors. Einstein's Summation Convention. Relation between Direction Cosines. Algebra of Tensors: Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Anti-symmetric Tensor of Order Two and Vectors.

Unit II **(8 Hours)**

Vector Calculus using Cartesian Tensors
Scalar and Vector Products of 2, 3, 4 vectors. Gradient, Divergence and Curl of Tensor Fields. Tensor notation of Laplacian operator. Proof of Vector Identities involving scalar and vector products and vector identities involving Del operator using Tensor notation.

Unit III **(7 Hours)**

Applications of Cartesian Tensors
Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.

Unit IV **(20 Hours)**

Group Theory
Elementary properties of groups, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group. Permutation group. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel. Some special groups: SO(2), SO(3), SU(2), SU(3).

REFERENCES

Essential Readings

1) Vector Analysis and Cartesian Tensors, 3rd edition, D. E. Bourne, P. C. Kendall, 1992
2) Cartesian Tensors, H. Jeffreys, 1931, Cambridge University Press.
3) Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, 2010, Elsevier.
4) A Brief on Tensor Analysis, J. G. Simmonds, 1997, Springer.
5) Schaum's outlines series on Vector Analysis, M. Spiegel, 2nd edition, 2017.
6) Schaum's Outline Series on Tensor Calculus, D. Kay, Revised 1st edition, 2011.
7) An Introduction to Tensor Calculus and Relativity, D. F. Lawden, 2013, Literary Licensing
8) Matrices and tensors in physics by A. W. Joshi, 1995, New Age International Publications.
9) Group Theory and its Applications to Physical Problems, by Morton Hamermesh, Dover Publications (1989).
10) Elements of Group Theory for Physicists, by A. W. Joshi, John Wiley (1997).

Additional Readings

1) A Student's Guide to Vectors and Tensors, D. A. Fleisch, 2011, Cambridge Univ. Press.
2) The Feynman Lectures on Physics, Volume II, Feynman, Leighton and Sands, 2008, Narosa Publishing House.
3) A Primer in Tensor Analysis and Relativity, I. L. Shapiro, 1st edition, 2019, Springer.
4) Group Theory and Physics, S. Sternberg, Cambridge University Press (1994).
5) Group Theory and Quantum Mechanics, Michael Tinkham, Dover Publications (2003)

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7-2 : CLASSICAL DYNAMICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Classical Dynamics DSE 7-2	4	3	1	0	

COURSE OBJECTIVES

- To introduce variational principles and their application to derive equations of motion for complex systems with constraints.
- To deepen the understanding of foundational principles of Classical Mechanics including Lagrangian and Hamiltonian formalisms
- To Develop an understanding of symmetries and conservation laws through Noether's Theorem
- To Analyze the motion of particles in central force fields, including planetary motion and scattering.
- To Explore the behavior of systems undergoing small oscillations, with emphasis on coupled systems and normal modes
- To describe motion in non-inertial frames and the dynamics of rigid bodies.

LEARNING OUTCOMES

By the end of this course, students will be able to:

- Apply the calculus of variations to derive the Euler-Lagrange equations and use them to analyze constrained mechanical systems.
- Use generalized coordinates and cyclic variables to simplify and solve problems in classical dynamics.
- Formulate and analyze mechanical systems using Lagrangian and Hamiltonian formalisms.
- Construct and analyze Hamiltonian systems, including canonical equations, and Poisson brackets.
- Analyze the motion of particles under central forces and solve scattering problems.
- Understand and compute normal modes and normal frequencies in small oscillation problems, including coupled oscillators.

- Describe motion in rotating frames and identify fictitious forces like centrifugal and Coriolis forces.
- Understand the dynamics of rigid bodies.
- Develop critical thinking and problem-solving skills

SYLLABUS OF DSE 7-2
THEORY COMPONENT
(Hours: 45)

Unit I **(16 Hours)**

Lagrangian and Hamiltonian Formulation
Calculus of Variation with examples, Generalized coordinates, Hamilton's Principle and Euler-Lagrange equations of motion. Constrained systems (holonomic). Applications of Euler-Lagrange Equation. Generalised Momenta and forces, Cyclic coordinates. Noether's Theorem and Conservation Principles.
Legendre transformation, Hamilton's equations and applications. Phase space and phase trajectories. Poisson brackets and its properties.

Unit II **(12 Hours)**

Central Force and Orbital Mechanics
Feature of Motion under Central Forces. Reduction of two body problem to equivalent one body problem. Effective potential, Energy diagrams. Equation of motion under central force and its formal solution. Classification and Stability of orbits**,** Conditions for Closed Orbits (Bertrand's Theorem). Kepler's laws for planetary motion, Scattering in central force field with example of Rutherford scattering, Transformation of scattering problem to laboratory coordinates.

Unit III **(9 Hours)**

Theory of small oscillations
Stable equilibrium and small amplitude oscillations. Solution of Eigenvalue equation. Normal modes and normal frequencies of oscillations. Damped and Forced Oscillations, Coupled oscillators.
Non-Inertial Frames
Non-inertial frames and fictitious forces. Uniformly rotating frames. Centrifugal and Coriolis forces.

Unit IV **(8 Hours)**

Rigid Body Dynamics
Rotation matrices, Euler angles. Angular momentum and rotational kinetic energy of rigid bodies, Moment of Inertia Tensor. Euler's equations of motion for rigid body. Torque-free motion.

REFERENCES

Essential Readings

1. The Feynman Lectures on Physics, Volume I and II, R. P. Feynman, R. B. Leighton and M. Sands, California Institute of Technology (2010).
2. Classical Mechanics, H. Goldstein, C. P. Poole, J. L. Safko, 3/e, Pearson Education (2014).
3. Classical Mechanics, John R. Taylor, University Science Books (2005).
4. Classical Mechanics, R. Douglas Gregory, Cambridge University Press (2015).
5. Mechanics, L. D. Landau and E. M. Lifshitz, Pergamon (2010).
6. Classical Mechanics, P. S. Joag, N. C. Rana, McGraw Hall Education (2017).
7. Classical Mechanics, Tai L. Chow, CRC Press (2013).

Additional Readings

1. Analytical Mechanics: Solutions to Problems in Classical Physics, I. Merches, D. Radu, CRC Press (2015).
2. Solved Problems in Classical Mechanics, O. L. Delange and J. Pierrus, Oxford University Press (2010).
3. Classical Dynamics of particles and system, S. T. Thornton, J. B. Marion, 2012, Cengage Learning.
4. Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, McGraw Hill Education (1977).

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7-3: ELECTRIC CIRCUIT ANALYSIS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Electric Circuit Analysis DSE 7-3	4	2	0	2	

COURSE OBJECTIVES

This course covers the basic circuit concepts in a systematic manner which is suitable for analysis and design. It aims at study and analysis of electric circuits using network theorems and two-port parameters.

LEARNING OUTCOMES

By the end of this course, the student will be able to:

- Explain the laws and methods of analysing DC and AC networks
- Define nodal and loop analysis
- Solve complex electric circuits using network theorems.
- Discuss resonance in series and parallel circuits and also the importance of initial conditions and their evaluation.
- Evaluate the performance of two port networks.
- Use Millman's theorem to reduce multiple voltage sources in parallel to a single equivalent voltage source.

SYLLABUS OF DSE 7-3
THEORY COMPONENT
(Hours: 30)

Unit I **(8 Hours)**

Circuit Analysis: Ideal voltage source, real voltage source, current source, Kirchhoff's current law, Kirchhoff's voltage law, node analysis, mesh analysis, Star and Delta conversion DC Transient Analysis: Charging and discharging with initial charge in RC circuit, RL circuit with initial current, time constant, RL and RC Circuits with source

Unit II **(5 Hours)**

AC Circuit Analysis: Sinusoidal voltage and current, Definitions of instantaneous, peak to peak, root mean square and average values, form factor and peak factor (for half-rectified and full-rectified sinusoidal wave, rectangular wave and triangular wave)

Unit III **(7 Hours)**

Voltage-current relationship in resistor, inductor and capacitor, phasor, complex impedance, power in AC circuits, sinusoidal circuit analysis for RL, RC and RLC Circuits, resonance in series and parallel RLC Circuits (Frequency Response, Bandwidth, Quality Factor), selectivity, application of resonant circuits

Unit IV **(10 Hours)**

Network Theorems: Principal of duality, Superposition theorem, Thevenin theorem, Norton theorem, Their applications in DC and AC circuits with more than one source, Maximum Power Transfer theorem for AC circuits, Reciprocity Theorem, Millman's Theorem, Tellegen's theorem Two Port Networks: Impedance (Z) Parameters, Admittance (Y) Parameters, Transmission Parameters, Impedance matching

PRACTICAL COMPONENT: ELECTRIC CIRCUIT ANALYSIS
(Hours: 60)

Every student must perform at least seven experiments from the following list of experiments:

1. Verification of Kirchoff's Law.
2. Verification of Superposition Theorem by using d.c. and a.c. voltage source
3. Verification of Norton's theorem.
4. Verification of Thevenin's Theorem and Maximum Power Transfer Theorem by using d.c. and a.c. voltage sources,
5. Determination of unknown capacitance using de Sauty's Bridge
6. Determination of time constant of RC and RL circuit
7. Study of frequency response of RC circuit
8. Study of frequency response of a parallel LCR Circuit and determination of its resonant frequency, impedance at resonance, quality factor and bandwidth.
9. Explore electrical properties of matter using Arduino:
    a. To study the characteristics of a series RC Circuit.
    b. To study the response curve of a series LCR circuit and determine its resonant frequency, impedance at resonance, quality factor and bandwidth

REFERENCES

1) A Textbook of Electrical Technology, B. L. Thareja, A. K. Thareja, Volume II, S. Chand
2) Fundamentals of Electric Circuits, C. Alexander and M. Sadiku, McGraw Hill (2008)
3) Electric Circuits, S. A. Nasar, Schaum’s Outline series, Tata McGraw Hill (2004)
4) Electrical Circuits, K. A. Smith and R.E. Alley, 2014, Cambridge University Press
5) Electrical Circuit Analysis, K. Mahadevan and C. Chitran, 2nd Edition, 2018, PHI Learning Pvt. Ltd.

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7-4 : MICROPROCESSOR

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Microprocessor DSE 7-4	4	2	0	2	

COURSE OBJECTIVES

Students will be able to outline the types and the functions of storage, learn the characteristics of RAM and ROM and their architecture, describe the architecture of 8085 microprocessors and develop programs for microprocessor 8085

LEARNING OUTCOMES

At the end of the course, students will develop ability to,

- Define storage state the types and functions of storage
- Describe the characteristics of RAM and ROM and their architecture.
- Describe memory organization, addressing, interfacing and mapping
- Describe the architectures of 8085 microprocessors
- Draw timing diagram
- Write programs using 8085

SYLLABUS OF DSE 7-4
THEORY COMPONENT
(Hours: 30)

Unit I **(8 Hours)**

Introduction to 8085 Microprocessor
Introduction to microprocessor: Basic computer system organization, introduction, classification and applications of microprocessors, types of memory-primary memory types (SRAM, DRAM, PROM, EPROM, EEPROM), secondary memory (SSD, Optical Drive) memory organization and addressing

Unit II **(8 Hours)**

Microprocessor 8085 Architecture

Features, architecture-block diagram, general purpose registers, register pairs, flags, stack pointer, program counter, types of buses, multiplexed address and data bus, generation of control signals, pin description of microprocessor 8085, basic memory interfacing concepts, Memory mapped I/O and I/O mapped I/O.

Unit III **(7 Hours)**

8085 Programming

Operation code, operand and mnemonics, instruction set of 8085, instruction classification, addressing modes, instruction format, data transfer instructions, arithmetic instructions, increment & decrement instructions, logical instructions, branch instructions and machine control instructions, subroutine, call and return instructions, timing diagrams-instruction cycle, machine cycle, T- states, basic idea of interrupts

Unit IV **(7 Hours)**

Assembly language programming

Addition with and without carry, subtraction with and without borrow, double addition, multiplication by repeated addition, division by repeated subtraction, block data transfer and checking of parity of a binary number.

PRACTICAL COMPONENT: MICRPROCESSOR
(Hours: 60)

At least six experiments to be performed from the following list:

8085 Assembly language programs

1. Add two 8-bit numbers using Direct and Indirect Addressing Mode
2. Subtract two 8-bit numbers using Direct and Indirect Addressing Mode
3. Multiply two 8-bit numbers with and without subroutine
4. Divide two 8-bit numbers with and without subroutine
5. Add a list of 8-bit numbers
6. Transfer a Block of Data
7. Add two 16-bit numbers with DAD and without DAD
8. Convert byte to Nibble
9. Convert nibble to Byte
10. Check the parity of a given number

REFERENCES

Essential Readings for the Theory Component

1. Microprocessor Architecture Programming and applications with 8085, R. S. Gaonkar, 2002, Prentice Hall
2. Microelectronic Circuits, S. Sedra
3. Fundamentals of Microprocessor and Microcomputer, B. Ram, Dhanpat Rai Publications
4. The Intel Microprocessors - Architecture, Programming and Interfacing, B. Brey, 2003, Pearson Education

Additional Readings for the Theory Component

Microprocessors and Microcontrollers, M. Ali Mazidi, 2006, Pearson

References for the Practical Component

1. Microprocessor Architecture Programming and applications with 8085, R. S. Gaonkar, 2002, Prentice Hall.
2. Microelectronic Circuits, S. Sedra.
3. Fundamentals of Microprocessor and Microcomputer, B. Ram, Dhanpat Rai Publications.
4. Microprocessors and Microcontrollers, M. Ali Mazidi, 2006, Pearson.
5. The Intel Microprocessors - Architecture, Programming and Interfacing, B. Brey, 2003, Pearson Education.

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7-5: NANOSCIENCE

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Nanoscience DSE 7-5	4	2	0	2	

COURSE OBJECTIVES

The syllabus introduces the basic concepts of nanomaterials, their synthesis, properties exhibited by them and finally few applications. Various nanomaterial synthesis/growth methods and characterizations techniques are discussed to explore the field in detail. The effect of dimensional confinement of charge carries on the electrical, optical and structural properties will be discussed. Interesting experiments which shape this filed like conductance quantization in 2DEG (Integer Quantum Hall Effect) and coulomb blockade are introduced. The concept of micro- and nano- electro mechanical systems (MEMS and NEMS) and important applications areas of nanomaterials are discussed.

LEARNING OUTCOMES

On successful completion of the course students should be able to

- explain the difference between nanomaterials and bulk materials and their property difference.
- explain various methods for the synthesis/growth of nanomaterials.
- explain the role of confinement on the density of state function and so on the various properties exhibited by nanomaterials compared to bulk materials.
- explain the concept of Quasi-particles such as excitons and how they influence the optical properties.
- explain the direct and indirect bandgap semiconductors, radiative and non-radiative processes and the concept of luminescence.
- explain the structure of 2DEG system and its importance in quantum transport experiments, like Interger Quantum Hall Effect and conductance quantization.
- explain the conductance quantization in 1D structure and its difference from the 2DEG system.

- explain the necessary and sufficient conditions required to observe coulomb blockade, single electron transistor and the scope of these devices.
- explain how MEMS and NEMS devices are produced and their applications.

SYLLABUS OF DSE 7-5
THEORY COMPONENT
(Hours: 30)

Unit I **(11 Hours)**

Introduction
Basic Introduction to Nano-Science and Technology - Implications on nanoscience on fields like Physics, Chemistry, Biology and Engineering, Classifications of nanostructured materials as quantum dots (0D), nanowires (1D), Thin films (2D) and Multi-layered materials or super lattices. Introduction to properties like Mechanical, Electronic, Optical, Magnetic and Thermal properties and how they change at Nano scale dimensions to motivate students (qualitative only).
Nanoscale Systems
Brief review of Schrodinger equation and its applications in- Infinite potential well, potential step and potential box problems, Band Structure and Density of states of 3D and 2D systems in detail and qualitatively for 1D and 0D, confinement of charges in nanostructures their consequences on electronic and optical properties.

Unit II **(10 Hours)**

Properties of Nano Scale systems
Time and length scales (diffusion, elastic and inelastic lengths etc.) of electrons in nanostructured materials, Carrier transport in nanostructures: diffusive and ballistic transport.
2D nanomaterials: Conductance quantization in 2DEG in GaAs and integer quantum hall effect (semi-classical treatment)
1D nanomaterials: Conductance quantization in 1D structures using split gate in 2DEG system (Qualitative).
0D nanomaterials: Charging effect, Coulomb Blockade effect, Single Electron Transfer (SET) device.
Basic understanding of excitons in semiconductors and their consequence on optical properties of the material

Unit III **(5 Hours)**

Synthesis of Nanomaterials (Qualitative)
Top-down and Bottom-up approach, Ball milling, Spin Coating
Vacuum deposition: Physical vapor deposition (PVD): Thermal evaporation, Sputtering, Chemical vapor deposition (CVD). Preparation of colloidal solutions of Metals, Metal Oxide nanoparticles

Unit IV **(4 Hours)**

Applications (Qualitative)

Micro Electromechanical Systems (MEMS), Nanoelectromehanical Systems (NEMS). Applications of nanomaterials as probes in medical diagnostics and targeted drug delivery, sunscreen, lotions, and paints and other examples to give broader perspective of applications of nanomaterials.

PRACTICAL COMPONENT: NANOSCIENCE

(Hours: 60)

At least 06 experiments from the following:

1. Synthesis of metal (e.g. Ag) nanoparticles by chemical route and study its optical absorption properties.
2. Synthesis of semiconductor (CdS/ZnO/TiO_2/Fe_2O_3 etc) nanoparticles and study its Optical Absorption properties as a function of ageing time.
3. Surface Plasmon study of metal nanoparticles as a function of size by UV-Visible spectrophotometer.
4. Analysis of XRD pattern of given nanomaterial and estimate lattice parameters and particle size.
5. To study the effect of the size nanoparticles on its color.
6. To prepare composite of CNTs with other materials and study their optical absorption/Transmission properties.
7. Growth of metallic thin films using thermal evaporation technique.
8. Prepare a ceramic disc of a given compound and study its I-V characteristics, measure its dielectric constant or any other property.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study its transmittance spectra in UV-Visible region.
10. Prepare thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN junction diode by diffusing Al over the surface of N-type Si/Ge and study its V-I characteristic.
12. Fabricate thin films (polymer, metal oxide) using electro-deposition
13. To study variation of resistivity or sheet resistance with temperature of the fabricated thin films using four probe method.

REFERENCES

Essential Readings for the Theory Component

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt. Ltd..
2. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company)

3. K. K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Introduction to Nanoelectronics, V. V. Mitin, V.A. Kochelap and M.A. Stroscio,2011, Cambridge University Press.
5. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).
6. Introductory Nanoscience by Masaru Kuno, (2012) Garland science Taylor and Francis Group
7. Electronic transport in mesoscopic systems by Supriyo Datta (1997) Cambridge University Press.
8. Fundamentals of molecular spectroscopy by C. N. Banwell and E. M. McCASH, 4th edition, McGrawHill.

Additional Readings for the Theory Component

1. Quantum Transport in semiconductor nanostructures by Carla Beenakker and HenK Van Houten (1991) (available at arXiv: cond-mat/0412664) Open Source
2. Sara Cronewett Ph.D. thesis (2001) for extra reading (Available as Arxiv).
3. Solid State Physics by J. R. Hall and H. E. Hall, 2nd edition (2014) Wiley

References for the Practical Component

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt. Ltd..
2. S. K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company)
3. K. K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7-6: QUANTUM MECHANICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Quantum Mechanics DSE 7-6	4	3	1	0	

COURSE OBJECTIVES

The development of quantum mechanics has revolutionized human life. In this course, students will be exposed to the probabilistic concepts of basic non-relativistic quantum mechanics and its applications to understand the subatomic world.

LEARNING OUTCOMES

After completing this course, the students will be able to

- Solve Schrödinger equation for different 1-d potentials, such as finite square potential well, potential steps and barriers and distinguish between scattering and bound states.
- Use the algebraic method to solve the Schrödinger equation for quantum harmonic
- Solve the 3-D Schrodinger equation in spherical coordinates.
- Understand the spectrum and eigenfunctions for hydrogen atom
- Understand the angular momentum operators in position space, their commutators, eigenvalues and eigenfunctions.
- Explain the concept of spin, use Pauli matrices to describe spin-½ systems, and construct the singlet and triplet spin states for two-particle systems.

SYLLABUS OF DSE 7-6
THEORY COMPONENT
(Hours: 45)

Unit I **(12 Hours)**

Schrödinger Equation for 1- dimensional systems
General solution of 1-D Schrödinger equation for time independent potentials, Solution of Schrödinger equation for a particle in a finite square potential well, reflection and transmission across a step potential and a rectangular potential barrier.
General discussion of bound states in an arbitrary potential: Continuity of wave function, boundary conditions and emergence of discrete energy levels with Application to energy eigenstates for a particle in a finite square potential well.

Unit II **(8 Hours)**

Structure and Time Evolution of Quantum States
Momentum space wavefunction, Time evolution of Gaussian Wave packet, Superposition Principle, linearity of Schrodinger Equation, General solution as a linear combination of discrete stationary states, Observables as operators, Commutator of position and momentum operators, Ehrenfest's theorem.
Harmonic oscillator
Energy eigenvalues and eigenstates of a 1-D harmonic oscillator using the algebraic method (ladder operators). Zero-point energy and the uncertainty principle.

Unit III **(12 Hours)**

Schrödinger Equation in three dimensions
Probability and probability densities in 3D. Schrödinger equation in spherical polar coordinates, its solution for the Hydrogen atom solution using separation of angular and radial variables. Solution of angular equation, Spherical harmonics.
Solution of radial equation using Frobenius method, Radial wavefunctions, Probability densities for ground and first excited states, quantum numbers n, l and m_l.

Unit IV **(13 Hours)**

Angular Momentum: Orbital Angular momentum operators ($\mathbf{L_x}$, $\mathbf{L_y}$ and $\mathbf{L_z}$) and ladder operators $\mathbf{L_+}$ and $\mathbf{L_-}$ as differential operators in cartesian coordinates and their commutation relations, Orbital angular momentum operators in spherical polar coordinates, their eigenvalues, eigenfunctions and identification of these with spherical harmonics.
Concept of spin: Spin angular Momentum Operator, Pauli matrices, algebraic theory of spin, General state for spin-1/2 particles, Total spin for a system of two spin-1/2 particles, singlet and triplet states.

REFERENCES

Essential Readings

1. Quantum Mechanics: Theory and Applications, Ajoy Ghatak and S. Lokanathan, Laxmi Publications (2019).
2. Introduction to Quantum Mechanics, D.J. Griffith, Pearson Education (2005).
3. A Textbook of Quantum Mechanics, P.M. Mathews and K. Venkatesan, McGraw-Hill (2010).
4. Quantum Mechanics, B. H. Bransden and C. J. Joachain, Prentice Hall (2000).
5. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, John Wiley and Sons, Ltd. (2009).

Additional Readings

1. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, Cambridge University Press (2008).
2. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications (1966).
3. Quantum Mechanics, Leonard I. Schiff, Tata McGraw Hill (2010).
4. Quantum Mechanics, Robert Eisberg and Robert Resnick, Wiley (2002).
5. Schaum's Outlines of Quantum Mechanics, Yoav Peleg, Reuven Pnini, Elyahu Zaarur, Eugene Hecht, NcGrawHill (2010).
6. Introductory Quantum Mechanics, R. L. Liboff; 4th Ed., Addison Wesley (2003).

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7-7 : SEMICONDUCTOR DEVICES - FABRICATION AND APPLICATIONS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Semiconductor Devices - Fabrication and Applications DSE 7-7	4	2	0	2	

COURSE OBJECTIVES

- This course provides a review of basics of semiconductors such as energy bands, doping, defects etc. and introduces students to various semiconductor and memory devices.
- Thin film growth techniques and processes including various vacuum pumps, sputtering, evaporation, oxidation and VLSI processing are described in detail.
- By the end of the syllabus, students will have an understanding of MEMS based transducers.

LEARNING OUTCOMES

At the end of this course, students will be able to achieve the following learning outcomes:

- Learn to distinguish between single crystal, polycrystalline and amorphous materials based on their structural morphology and learn about the growth of single crystals of silicon, using Czochralski technique, on which a present day electronics and IT revolution is based. Students will understand about the various techniques of thin film growth and processes.
- Appreciate the various VLSI fabrication technologies and learn to design the basic fabrication process of R, C, P- N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology.
- Gain basic knowledge on overview of MEMS (MicroElectro-Mechanical System) and MEMS based transducers.

SYLLABUS OF DSE 7-7
THEORY COMPONENT
(Hours: 30)

Unit I **(9 Hours)**

Introduction: Review of energy bands in materials. Metal, Semiconductor and Insulator. Doping in Semiconductors, Defects: Point, Line, Schottky and Frenkel. Single Crystal, Polycrystalline and Amorphous Materials. Czochralski technique for Silicon Single Crystal Growth. Silicon Wafer Slicing and Polishing.

Vacuum Pumps: Primary Pump (Mechanical) and Secondary Pumps (Diffusion, Turbomolecular, Cryopump, Sputter - Ion)– basic working principle, Throughput and Characteristics in reference to Pump Selection. Vacuum Gauges (Pirani and Penning).

Unit II **(10 Hours)**

Thin Film Growth Techniques and Processes: Sputtering, Evaporation (Thermal, electronBeam), Pulse Laser Deposition (PLD), Chemical Vapor Deposition (CVD). Epitaxial Growth. Thermal Oxidation Process (Dry and Wet) Passivation. Metallization. Diffusion.

Unit III **(7 Hours)**

VLSI Processing: Clean Room Classification, Line width, Photolithography: Resolution and Process, Positive and Negative Shadow Masks, Photoresist, Step Coverage, Developer. Electron Beam Lithography. Etching: Wet Etching. Dry etching (RIE and DRIE). Basic Fabrication Process of R, C, P-N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology. Wafer Bonding, Wafer Cutting, Wire bonding and Packaging issues (Qualitative idea).

Unit IV **(4 Hours)**

Micro Electro-Mechanical System (MEMS): Introduction to MEMS, Materials selection for MEMS Devices, Selection of Etchants, Surface and Bulk Micromachining, Sacrificial Subtractive Processes, Additive Processes, Cantilever, Membranes. General Idea MEMS based Pressure, Force, and Capacitance Transducers.

PRACTICAL COMPONENT: SEMICONDUCTOR DEVICES - FABRICATION AND APPLICATIONS
(Hours: 60)

At least 06 experiments from the following:

1. Fabrication of thin films via dip-coating technique, deposition of metal contacts through thermal evaporation and investigation of their current–voltage (I–V) characteristics.
2. Fabrication of thin films via spin-coating technique, deposition of metal contacts through thermal evaporation and investigation of their current–voltage (I–V) characteristics

3. Fabrication of p-n junction using either p or n type substrate along with appropriate semiconducting layer and study its current-voltage (I-V) Characteristics.
4. Generation of vacuum in small tubes (varying volumes) using a mechanical rotary pump and measurement of pressure using vacuum gauges.
5. Selective etching of Different Metallic thin films using suitable etchants of different concentrations.
6. Wet chemical etching of Si for Micro-Electro-Mechanical Systems (MEMS) applications using different concentrations of etchant.
7. Calibrate semiconductor type temperature sensor (AD590, LM 35, LM 75).
8. To measure the resistivity of a germanium (Ge) semiconductor crystal with temperature (up to 150 ^{o}C) by four-probe method.
9. Capacitance measurements of ceramics using LCR meter.
10. Capacitance measurements of dielectric thin film capacitor using LCR meter

REFERENCES

Essential Readings for the Theory Component

1. Physics of Semiconductor Devices, S. M. Sze. Wiley-Interscience.
2. Fundamentals of Semiconductor Fabrication, S.M. Sze and G. S. May, John-Wiley and Sons, Inc.
3. Introduction to Semiconductor materials and Devices, M. S. Tyagi, John Wiley & Sons VLSI Fabrication Principles (Si and GaAs), S. K. Gandhi, John Wiley & Sons, Inc.

Additional Readings for the Theory Component

Handbook of Thin Film Technology, Leon I. Maissel and Reinhard Glang.

References for the Practical Component

1. The science and Engineering of Microelectronics Fabrication, Stephen A. Champbell, 2010, Oxford University Press.
2. Introduction to Semiconductor Devices, Kelvin F.

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

SKILL BASED COURSE – SBC 7-1:
ARDUINO PROGRAMMING

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Arduino Programming SBC 7-1	2	0	0	2	

COURSE OBJECTIVES

- To introduce students to the fundamentals of embedded systems using the Arduino platform.
- To develop programming skills in C/C++ for microcontroller-based applications.
- To foster logical thinking and problem-solving through real-world electronic projects.
- To lay the foundation for interfacing sensors and actuators using digital and analog I/O.

LEARNING OUTCOMES

- Explain the architecture and features of the Arduino Platform.
- Set up and use the Arduino IDE to write, debug using Serial Monitor, and upload code to an Arduino board.
- Write basic programs involving digital and analog I/O, loops, functions, and conditional statements.
- Implement simple tasks such as blinking LEDs, reading buttons, generating PWM signals, and reading analog voltages.
- Understand serial communication and use the Serial Monitor for debugging.
- Design small-scale automation and control programs using Arduino logic.

SYLLABUS OF SBC 7-1
(Hours: 60)

Unit I **(24 Hours)**

Introduction to Arduino

- Overview of Arduino and its applications.
- Understanding microcontrollers and development boards.

- Introduction to the Arduino IDE.
- Installing the Arduino IDE.
- Connecting Arduino to your computer.
- First program: Blink an LED (Hello World of Arduino).

Basic Electronic Components

- Basic concepts of electronic components- Resistors, capacitors, diodes, transistors, LEDs.
- Breadboards and prototyping techniques.
- Ohm’s Law and calculating resistor values for LEDs.
- Controlling LEDs with Arduino.
- Switches and Buttons: Digital inputs and outputs. Using push buttons with Arduino.

Unit II **(36 Hours)**

Programming Fundamentals

- Arduino Programming Basics: Structure of an Arduino sketch (setup and loop functions), Variables, data types, and operators.
- Control Structures: Conditional statements (if, else, switch). Loops (for, while, do-while).
- Functions and Libraries: Writing and using functions. Introduction to Arduino libraries.
- Debugging and Troubleshooting: Common errors and debugging techniques. Serial communication (Serial Monitor) for debugging.

List of Experiments

1. Blink an LED. Also modify blink rate.
2. Button-Controlled LED. Turn an LED on/off using a push button.
3. Debounce a Button. Implement debounce to handle noisy button presses.
4. LED Fading to control LED brightness.
5. Potentiometer-Controlled LED. Adjust LED brightness using potentiometer and analog Read().
6. Serial Monitor Interaction. Display text and sensor readings on the Serial Monitor.
   16x2 LCD Display. Display "Hello, World!" and temperature data.

Project-based learning to be encouraged.

SUGGESTED READINGS

“Getting Started With Arduino” By Massimo Banzi and Michael Shiloh. Shroff/Maker Media; fourth edition (2022). ISBN-13 : 978-9391043858

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – DSC 8-1: ELECTROMAGNETIC THEORY

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Electromagnetic Theory DSC 8-1	4	3	0	1	

COURSE OBJECTIVES

This core course develops further the concepts learnt in the electricity and magnetism course to understand the properties of electromagnetic waves in vacuum and different media.

LEARNING OUTCOMES

At the end of this course the student will be able to,

- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density
- Understand electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma
- Understand electromagnetic wave propagation in bounded media: reflection and transmission coefficients at plane interface in bounded media
- Understand polarization of electromagnetic waves: Linear, circular and elliptical polarization. Production as well as detection of waves in laboratory
- Learn the features of planar optical wave guide
- In the laboratory course, the students will get an opportunity to perform experiments with polarimeter, Babinet compensator, ultrasonic grating and simple dipole antenna. Also, to study phenomena of interference, refraction, diffraction and polarization

SYLLABUS OF DSC 8
THEORY COMPONENT
(Hours: 45)

Unit I **(6 Hours)**

Maxwell's equations; Coulomb gauge and Lorentz gauge; Poynting's theorem and Poynting's vector; electromagnetic (em) energy density; physical concept of electromagnetic field energy density

Unit II **(19 Hours)**

EM wave propagation in unbounded media: Plane em waves through vacuum and isotropic dielectric medium: transverse nature, refractive index, dielectric constant, wave impedance. Plane em waves through conducting medium: relaxation time, skin depth, attenuation constant; Wave propagation through dilute plasma: electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth.
EM waves in bounded media: Boundary conditions at a plane interface between two media; reflection and refraction of plane em waves at plane interface between two dielectric media - Laws of reflection and refraction; Fresnel's formulae for perpendicular and parallel polarization, Brewster's law; reflection and transmission coefficients; total internal reflection, evanescent waves; metallic reflection (normal incidence)

Unit III **(13 Hours)**

Polarization of EM waves: Propagation of em waves in an anisotropic media; symmetric nature of dielectric tensor; Fresnel's formula; uniaxial and biaxial crystals; light propagation in uniaxial crystal; double refraction; polarization by double refraction; Nicol prism; ordinary and extraordinary refractive indices; production and detection of plane, circular and elliptically polarized light; phase retardation plates: quarter wave and half wave plates

Unit IV **(7 Hours)**

Wave guides: Planar optical wave guides; planar dielectric wave guide ($-d/2 < x < d/2$); condition of continuity at interface; phase shift on total reflection; Eigenvalue equations; phase and group velocity of guided waves; field energy and power transmission (TE mode only).

<u>PRACTICAL COMPONENT: ELECTROMAGNETIC THEORY</u>
(Hours: 30)

- Mandatory sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.
- Mandatory sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.

At least six experiments to be performed from the following list:

7. To verify the law of Malus for plane polarized light.
8. To determine the specific rotation of sugar solution using polarimeter.
9. To analyse elliptically polarized light by using a Babinet's compensator.
10. To study the elliptical polarized light using Fresnel rhomb.
11. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.

12. To study the reflection and refraction of microwaves
13. To study polarization and double slit interference in microwaves.
14. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
15. To determine the refractive index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
16. To verify the Stefan's law of radiation and to determine Stefan's constant.
17. To determine Boltzmann constant using V-I characteristics of PN junction diode.
18. To find numerical aperture of an optical fibre.
19. To use a prism shaped double refracting crystal to determine the refractive indices of the quartz/ calcite corresponding to ordinary and extra-ordinary rays.
20. To measure birefringence of Mica
21. To determine the dielectric constant of solids using microwaves

REFERENCES

Essential Readings for the Theory Component

1) Introduction to Electrodynamics, D. J. Griffiths, 3rd edition, 1998, Benjamin Cummings.
2) Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd edition, 2003, CBS Publisher
3) Classical Electrodynamics, J. D. Jackson, 3rd edition, 2010, Wiley
4) Principle of Optics, M. Born and E. Wolf, 6th edition, 1980, Pergamon Press
5) Optics, A. Ghatak, 6th edition, 2017, McGraw-Hill Education, New Delhi

Additional Readings for the Theory Component

2) Electricity, Magnetism and Electromagnetic Theory, S. Mahajan, and S. R. Choudhary, 2017, TMH
3) Principles of Electromagnetic Theory, C. Jain, 2017, Narosa Publishing House
4) Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
5) Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill
6) Problems and solution in Electromagnetics, A. Ghatak, K. Thyagarajan and Ravi Varshney, 2015
7) Electromagnetic field Theory, R. S. Kshetrimayun, 2012, Cengage Learning
8) Engineering Electromagnetic, W. H. Hayt, 8th edition, 2012, McGraw Hill.
9) Electromagnetics, J. A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
10) 2008+ Solved Problems in Electromagnetics, S. A. Nasar, 2001, SciTech

References for the Practical Component

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publisher

3) Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
4) Practical Physics, G. L. Squires, 4th edition, 2015, Cambridge University Press
5) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-1 : APPLIED OPTICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Applied Optics DSE 8-1	4	2	0	2	

COURSE OBJECTIVES

This paper provides the conceptual understanding of various branches of modern optics to the students. This course introduces basic principles of LASER, Holography and signal transmission via optical fiber.

LEARNING OUTCOMES

At the end of this course, students will be able to

- Understand basic lasing mechanism qualitatively, types of lasers, characteristics of laser light and its application in developing LED, Holography.
- Gain concepts of Fourier optics and Fourier transform spectroscopy.
- Understand basic principle and theory of Holography.
- Grasp the idea of total internal reflection and learn the characteristics of optical fibers.

SYLLABUS OF DSE 8-1
THEORY COMPONENT
(Hours: 30)

Unit I **(8 Hours)**

Photo-sources and Detectors Lasers
Absorption process, Spontaneous and stimulated emission processes, Theory of laser action, Population of energy levels, Einstein's coefficients and optical amplification, properties of laser beam, Ruby laser, He-Ne laser and semiconductor lasers. Light Emitting Diode (LED) and photo-detectors.

Unit II **(7 Hours)**

Fourier Optics

Fourier Optics and Fourier Transform Spectroscopy (Qualitative explanation). Concept of Spatial frequency filtering, Fourier transforming property of a thin lens, Fourier Transform Spectroscopy (FTS): measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry, and forensic science.

Unit III

Holography Introduction **(7 Hours)**

Basic principle and theory: recording and reconstruction processes, Requirements of holography- coherence, etc. Types of holograms: The thick or volume hologram, Multiplex hologram, white light reflection hologram; application of holography in microscopy, interferometry, and character recognition.

Unit IV **(8 Hours)**

Photonics

Optical fibres: Total Internal Reflection, Basic characteristics of the optical fibre: Principle of light propagation through a fibre, the coherent bundle, The numerical aperture, Attenuation in optical fibre and attenuation limit; Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating.

PRACTICAL COMPONENT: APPLIED OPTICS
(Hours: 60)

College to set up at least 10 experiments from the listed experiments. *At least 6 experiments to be performed by students from amongst the experiments offered.*

Experiments on Lasers

1. To determine the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid-state laser.
2. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid-state laser.
3. To find the polarization angle of laser light using polarizer and analyzer,
4. Thermal expansion of quartz using laser
5. To determine the wavelength and angular spread of laser light by using plane diffraction grating.

Experiments on Semiconductor Sources and Detectors

1. V-I characteristics of LED.
2. Study the characteristics of solid state laser.
3. Study the characteristics of LDR.
4. Characteristics of Photovoltaic Cell/ Photodiode.
5. Characteristics of IR sensor.

Experiments on Fourier Optics

1. Optical image addition/subtraction.
2. Optical image differentiation.
3. Fourier optical filtering.
4. Construction of an optical 4f system

Experiment on Fourier Transform Spectroscopy

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

Experiments on Holography and interferometry

1. Recording and reconstruction of holograms (Computer simulation can also be done).
2. To construct a Michelson interferometer or a Fabry Perot interferometer.
3. To determine the wavelength of sodium light by using Michelson's interferometer.
4. To measure the refractive index of air.

Experiments on Fibre Optics

1. To measure the numerical aperture of an optical fibre
2. To measure the near field intensity profile of a fibre and study its refractive index profile
3. To study the variation of the bending loss in a multimode fibre
4. To determine the power loss at a splice between two multimode fibre
5. To determine the mode field diameter (MFD) of fundamental mode in a single mode fibre by measurements of its far field Gaussian pattern

REFERENCES

1. Introduction to Fourier Optics, Joseph W. Goodman, The McGraw- Hill, 1996.
2. Introduction to Fiber Optics, A. Ghatak & K. Thyagarajan, Cambridge University Press.
3. Fibre optics through experiments, M. R. Shenoy, S. K. Khijwania, et.al. 2009, Viva Books
4. Optical Electronics, Ajoy Ghatak and K. Thyagarajan, 2011, Cambridge University Press
5. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-2 : ATMOSPHERIC PHYSICS AND CLIMATE CHANGE

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Atmospheric Physics and Climate Change DSE 8-2	4	3	0	1	

COURSE OBJECTIVES

This course familiarizes the students with the atmospheric processes, and vertical thermal and dynamical features in the lower and middle atmosphere. It enables to learn remote sensing techniques to explore atmospheric processes and helps to understand long term oscillations and fluid system dynamics which control climate change. Also, it delineates characteristics of pollutants and aerosols variability in the lower and middle atmosphere. Another important aspect would be how the different atmospheric and meteorological parameters are changing over a period of time from Climate change perspective.

LEARNING OUTCOMES

By successfully completing this course students will be able to,

- Have an overview of thermal structure of the Earth's atmosphere as well as various dynamical processes occurring in different layers of the atmosphere.
- Develop an understanding of remote sensing techniques such as radar, satellite, and lidar systems.
- Understand the origin of different atmospheric oscillations, which are prominent at different altitudes. In addition, understating will be improved on several features of low- and high-pressure systems and wind circulation.
- Atmospheric and Ocean interaction can be learnt how they influence each other on long term time scales connected with such as El Niño Southern Oscillations (ENSO)
- Climate Change can be understood by using long term atmospheric data (both observations and model) and further exploring and utilization of different numerical techniques for the fine and long-term temporal and regional to global scales.
- Develop the problem-solving skills using observations and conducting simulations. This would clarify the fundamental processes and modifications under different conditions.

SYLLABUS OF DSE 8-2
THEORY COMPONENT
(Hours: 45)

Unit I **(10 Hours)**

General features of Earth's atmosphere
Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms. Dynamics of Particulate Matter (PM), pollutants and meteorological parameters diurnal, seasonal and annual variability. PM and their effect on human health.

Unit II **(13 Hours)**

Atmospheric Dynamics
Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale and general circulations.
Atmospheric Waves
Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration.

Unit III **(7 Hours)**

Remote Sensing Techniques (Atmospheric Radar)
Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Classification and properties of aerosols, Aerosol studies using Lidars.

Unit IV **(15 Hours)**

Climate Change
Historical trends of CO_2 and temperature, understanding on sea level rise. Thermodynamics in climatology, long term energy balance and cycles, and rudimentary introduction to climate change models. Physical processes of greenhouse gases warming the planet, Impact of climate change in extreme weather, regional case studies focus on India subcontinent, Climate policies and international agreement - UNFCCC, Kyoto Protocol, Paris Agreement, Role of COP meetings, Concept of Net-Zero Emission, and Climate Change and public health.

PRACTICAL COMPONENT: ATMOPHERIC PHYSICS AND CLIMATE CHANGE
(Hours: 30)

Atmospheric Physics

Scilab/Python/Matlab based simulations experiments based on Atmospheric Physics problems listed below.

At least 03 Experiments from the following should be conducted.

1. Numerical Simulation for atmospheric waves using dispersion relations for
    a. Atmospheric gravity waves (AGW)
    b. Kelvin waves
    c. Rossby waves, and
    d. mountain waves.
2. Processing of radar data a. VHF radar, b. X-band radar, and c. UHF radar,
3. Offline and online processing of LIDAR data.
4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe. Suggested parameters calculations are (i) Brunt Vaisala frequency, (ii) potential temperature, (iii) pressure-height conversion, and (iv) thermal wind equation.
5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique

Climate Change

i. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change.
ii. PM 2.5 measurement using compact instruments and experience with data from CPCB and DPCC to investigate the Climate Change.

Field visits to National centre for medium range weather forecasting, India meteorological departments, and ARIES Nainital to visualise onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

REFERENCES

Essential Readings for the Theory Component

1. Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3 rd edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

Additional Readings for the Theory Component

1. Stratosphere Troposphere Interactions - K Mohanakumar, Springer Netherlands, 2008.

2. Climate change in the Himalayas, Springer publication, by GB Pant, P Pradeep Kumar, J V Revadekar, Narendra Singh, 2018.
3. PM2.5 diminution and haze events over Delhi during the COVID-19 lockdown period: an interplay between the baseline pollution and meteorology, Nature- Scientific Reports, 10(13442). https://doi.org/10.1038/s41598- 020-70179-8., S. K. Dhaka, Chetna, V. Kumar, V. Panwar, A. P. Dimri, N. Singh, P. K. Patra, Y. Matsumi, M. Takigawa, and T. Nakayama (2020)
4. Gravity wave generation in the lower stratosphere due to passage of the typhoon 9426 (Orchid) observed by the MU radar at Shigaraki (34.85 N, 136.10 E), SK Dhaka, M Takahashi, Y. Shibagaki, MD Yamanaka, S Fukao, Journal of Geophysical Research: Atmosphere 108 (D19), 2003.
5. Indian MST radar observations of gravity wave activities associated with tropical convection, SK Dhaka, PK Devrajan, Y Shibagaki, RK Choudhary, S Fukao, Journal of Atmospheric and Solar-Terrestrial Physics 63 (15), 1631-1642.
6. Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques (https://www.narl.gov.in)

References for the Practical Component

Data sources for radar, lidar, satellite and radiosondes

1. https://www.narl.gov.in
2. http://www.imd.gov.in
3. https://www.ncmrwf.gov.in/
4. https://www.aries.res.in/
5. http://www.rish.kyoto-u.ac.jp/ear/index-e.html

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-3 : ATOMIC AND MOLECULAR PHYSICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Atomic and Molecular Physics DSE 8-3	4	3	1	0	

COURSE OBJECTIVES

This course introduces the basic concepts of atomic, molecular and nuclear physics to an undergraduate student. Advanced mathematics is avoided and the results of quantum mechanics are attempts to explain, or even to predict, the experimental observations of spectroscopy. The student will be able to visualize an atom or molecule as a physical entity rather than a series of mathematical equations.

LEARNING OUTCOMES

On successful completion of the module students should be able to elucidate the following main features.

- Stern-Gerlach experiment, electron spin, spin magnetic moments
- Space quantization and Zeeman effect
- Spectral notations for atomic and molecular states and corresponding term symbols
- Understanding of atomic spectra and molecular spectra
- Basic principle of Raman spectroscopy and Franck Condon principle
- To complete scientific potential lies on the way we are able to interpret the fundamental astrophysical and nuclear data. This acquired knowledge will be a common base for the areas of astrophysics, nuclear, medical, geology and other inter-disciplinary fields of Physics, Chemistry and Biology. Special skills required for the different fields will be enhanced.

SYLLABUS OF DSE 8-3
THEORY COMPONENT
(Hours: 45)

Unit I **(11 Hours)**

Atomic Physics
One-electron atoms: Degeneracy of energy levels and selection rules, modes of relaxation of an excited atomic state, line intensities and the lifetimes of excited states, line shapes and widths.
Fine structure of hydrogenic atoms: Shifting of energy levels, splitting of spectral lines, relativistic correction to kinetic energy, spin-orbit term, Darwin term, fine structure spectral lines, Lamb shift (qualitative idea).

Unit II **(12 Hours)**

Atoms in external magnetic fields: Larmor's theorem, Stern-Gerlach experiment, normal Zeeman effect, Paschen Back effect, and anomalous Zeeman effect, g-factors.
Two and multi-electron systems: Spin multiplicity, singlet and triplet states and selection rules in helium atom, central field approximation, Aufbau and Pauli exclusion principle, Slater determinant, LS and JJ coupling scheme (equivalent and non-equivalent electrons), term symbols and Hund's rule, Lande' interval rule.
Qualitative Discussion of Lamb shift and Auger effect.

Unit III **(11 Hours)**

Molecular Physics
Electronic states of diatomic molecules: Linear combination of atomic orbitals (LCAO), bonding and antibonding orbitals; 'gerade', 'ungerade', molecular orbitals and the ground state electronic configurations for homo and hetero-nuclear diatomic molecules, classification of molecular excited states of diatomic molecule, Vector representation of Orbital and electron spin angular momenta in a diatomic molecule, The Born-Oppenheimer approximation, Concept of Potential energy curve for a diatomic molecule, Morse potential. The Franck-Condon principle

Unit IV **(11 Hours)**

Molecular Spectra of diatomic molecule: Rotational Spectra (rigid and non-rigid rotor), Vibrational Spectra (harmonic and anharmonic), Vibration-Rotation Spectrum of a diatomic molecule, Isotope effect, Intensity of spectral lines
Raman Effect: Classical Theory (with derivation) of Raman effect, pure rotational Raman Lines, Stoke's and Anti-Stoke's Lines, comparison with Rayleigh scattering
Idea of spin resonance spectroscopy (Nuclear Magnetic Resonance, Electron Spin Resonance) with few examples, estimation of magnetic field of the Sun.

<u>REFERENCES</u>

Essential Readings

1. Physics of Atoms and Molecules, B. H. Bransden and C. J. Jochain, 2^{nd} edition, Pearson
2. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, 1994, Tata McGraw – Hill
3. Atomic physics, J. B. Rajam and foreword by Louis De Broglie, 2010, S. Chand and Co.
4. Atoms, Molecules and Photons, W. Demtroder, 2^{nd} edition, 2010, Springer
5. Atomic, Nuclear and. Particle Physics. Compiled by. The Physics Coaching Class. University of science and Technology of China, edited By Yung-Kuo Lim. World scientific.
6. Atomic Physics, S. N. Ghoshal, 2019, S. Chand Publication
7. Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman, G. A. Kriz and J. R. Vyvyan, 5^{th} edition, 2014, Brookes/Cole

Additional Readings

1. Basic Atomic and Molecular Spectroscopy, J. M. Hollas, Royal Society of Chemistry
2. Molecular Spectra and Molecular Structure, G. Herzberg
3. Introduction to elementary particles, D. J Griffiths, 2008, Wiley
4. Atomic and molecular Physics, R. Kumar, 2013, Campus Book Int.
5. The Fundamentals of Atomic and Molecular Physics, Undergraduate Lecture Notes in Physics, 2013, Springer

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-4: DIGITAL SIGNAL PROCESSING

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Digital Signal Processing DSE 8-4	4	2	0	2	

COURSE OBJECTIVES

- This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals.
- This paper also highlights the concept of filters and realization of Digital Filters.
- At the end of the syllabus, students will develop an understanding of Discrete and fast Fourier Transform.

LEARNING OUTCOMES

At the end of this course, students will be able to develop following learning outcomes:

- Students will learn basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear time-invariant (LTI) systems.
- The student will be in position to understand use of different transforms and analyze the discrete time signals and systems. They will learn to analyze a digital system using z-transforms and discrete time Fourier transforms, region of convergence concepts, their properties and perform simple transform calculations.
- The student will realize the use of LTI filters for filtering different real world signals. The concept of transfer Function and difference-Equation System will be introduced. Also, they will learn to solve Difference Equations.
- Students will develop an ability to analyze DSP systems like linear-phase, FIR, IIR, All-pass, averaging and notch Filter etc.
- Students will be able to understand the discrete Fourier transform (DFT) and realize its implementation using FFT techniques.
- Students will be able to learn the realization of digital filters, their structures, along with their advantages and disadvantages. They will be able to design and understand different types of digital filters such as finite & infinite impulse response filters for various applications.

SYLLABUS OF DSE 8-4
THEORY COMPONENT
(Hours: 30)

Unit I **(7 Hours)**

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical and Analytical Method, Properties of Convolution (General Idea); Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response.

Unit II **(9 Hours)**

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z- Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of- Convergence; Differentiation in the z-Domain; Power Series Expansion Method (General Idea). Transfer Function and Difference-Equation System.

Unit III **(10 Hours)**

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters (only qualitative treatment).
Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation (general idea), Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution).

Unit IV **(4 Hours)**

Realization of Digital Filters: FIR Filter structures; Direct-Form; Cascade-Form
Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR Filters.

PRACTICAL COMPONENT: DIGITAL SIGNAL PROCESSING
(Hours: 60)

Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors and application to the specific experiments done in the lab.

At least 06 experiments from the following using Scilab/Matlab/Python.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence *u(n)*, (c) ramp sequence *r(n)*, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \le n \le 50$.
2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for N = 5

$$\mathrm{x(n)} = \mathrm{rect}\left(\frac{\mathrm{n}}{2\mathrm{N}}\right) = \prod \quad \left(\frac{\mathrm{n}}{2\mathrm{N}}\right) = \{1 \quad -\mathrm{N} \le \mathrm{n} \le \mathrm{N}\ 0 \qquad \text{otherwise}$$

3. An LTI system is specified by the difference equation: y(n)=0.8y(n-1)+x(n)
   (a) Determine $\mathrm{H(e^{iw})}$
   (b) Calculate and plot the steady state response y(n) to $\mathrm{x(n)} =$cos cos $(0.5\pi\mathrm{n})\ \mathrm{u(n)}$
4. Given a casual system y(n)=0.9y(n-1)+x(n)
   (a) Find H(z) and sketch its pole-zero plot
   (b) Plot the frequency response $|H(e^{jw})|$ and $\angle H(e^{jw})$
5. Design a digital filter to eliminate the lower frequency sinusoid of *x(t)=sin7t+sin200t*. The sampling frequency is 500 Hz. Plot its pole zero diagram, magnitude response, input and output of the filter.
6. Let *x(n)* be a 4-point sequence:
   $x(n) = \{1,1,1,1\} = \{1 \;\; 0 \le n \le 3 \;\; 0 \;\; otherwise$

   Compute the DTFT $X(e^{jw})$ and plot its magnitude
   (a) Compute and plot the 4 point DFT of *x(n)*
   (b) Compute and plot the 8 point DFT of *x(n)* (by appending 4 zeros)
   (c) Compute and plot the 16 point DFT of *x(n)* (by appending 12 zeros)
7. Let *x(n)* and *h(n)* be the two 4-point sequences,
   x(n)={1,2,2,1} *h(n)={1,-1,-1,1}*

   Write a program to compute their linear convolution using circular convolution.
8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specifications:

Passband edge F_p=2 KHz
Stopband edge F_s=5 KHz
Passband attenuation A_p=2 dB
Stopband attenuation A_s=42 dB
Sampling frequency F_{sf}=20 KHz

10. The frequency response of a linear phase digital differentiator is given by

$$H_d(e^{jw}) = jwe^{-j\tau w} \; |w| \leq \pi$$

Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response

REFERENCES

Essential Readings for the Theory Component

1. Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
2. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
3. Principles of Signal Processing and Linear Systems, B.P. Lathi, 2009, 1st Edn. Oxford University Press.
1. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
2. Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4th Edn., Prentice Hall.

Additional Readings for the Theory Component

1. Digital Signal Processing, A. Anand Kumar, 2nd Edition, 2016, PHI learning Private Limited.
2. Digital Signal Processing, Paulo S.R. Diniz, Eduardo A.B. da Silva, Sergio L. Netto, 2nd Edition, 2017, Cambridge University Press.

References for the Practical Component

1. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.
2. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
3. Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-5 : NONLINEAR DYNAMICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Nonlinear Dynamics DSE 8-5	4	3	0	1	

COURSE OBJECTIVES

This course introduces the main topics of low-dimensional nonlinear systems, with applications to a wide variety of disciplines, including physics, engineering, mathematics, chemistry, and biology. This course begins with the first order dynamical system and the idea of phase space, flows and trajectories and ends with the elementary fluid dynamics. Students will also appreciate the introduction to chaos and fractals.

LEARNING OUTCOMES

Upon successful course completion, a student will be able to:

- Demonstrate understanding of the concepts that underlay the study of dynamical systems.
- Understand fractals as self-similar structures.
- Learn various forms of dynamics and different routes to chaos.
- Understand basic Physics of fluids and its dynamics theoretically and experimentally and by computational simulations
- In the Lab course, students will be able to perform Simulations/Lab experiments on: coupled Oscillators, Simulation of Simple Population, Predator-Prey Dynamics, Simple genetic circuits, rate equations for some simple chemical reactions, Fractal Formation in Deterministic Fractals, Fluid Flow Models.

<u>SYLLABUS OF DSE 8-5</u>
<u>THEORY COMPONENT</u>
(Hours: 45)

Unit I **(15 Hours)**

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems: simple and damped harmonic oscillator. Sketching flows and trajectories in phase space. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems. Examples of dynamical systems – Population models e.g. exponential growth and decay, logistic growth, predator- prey dynamics. Rate equations for chemical reactions e.g. auto catalysis, bi-stability.

Unit II **(15 Hours)**

Introduction to Chaos and Fractals: Chaos in nonlinear equations - Logistic map and Lorenz equations: Dynamics from time series. Parameter dependence- steady, periodic and chaotic states. Cobweb iteration. Fixed points. Defining chaos- a periodic, bounded, deterministic and sensitive dependence on initial conditions. Period- Doubling route to chaos.
Self-similarity and fractal geometry: Fractals in nature - trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure.

Unit III **(8 Hours)**

Elementary Fluid Dynamics: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis-concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties-viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state

Unit IV **(7 Hours)**

Flow phenomena
Flow dimensionality, steady and unsteady flows, uniform and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows. Flow visualization - streamlines, pathlines, streaklines.

PRACTICAL COMPONENT: NONLINEAR DYNAMICS
(Hours: 30)

Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems.
At least 06 experiments from the following:

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth,
5. predator-prey dynamics.
6. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
   (i) To study examples from game theory.
   (ii) To study period doubling route to chaos in logistic map.
   (iii)To study various attractors of Lorenz equations.
   (iv) Computational visualization of fractal formations of Deterministic fractal.
   (v) Computational visualization of fractal formations of self-similar fractal.
   (vi) Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
   (vii) Computational Flow visualization - streamlines, pathlines, streaklines.

REFERENCES

1. Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-6 : NUCLEAR AND PARTICLE PHYSICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Nuclear and Particle Physics DSE 8-6	4	3	1	0	

COURSE OBJECTIVES

The objective of the course is to impart the understanding of the sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application. The course will focus on the developments of problem-based skills.

LEARNING OUTCOMES

- To be able to understand the basic properties of nuclei: Nuclear charge and mass density, size, magnetic and electric moments
- To appreciate the formulations and contrasts between different nuclear models such as Liquid drop model, Fermi gas model and Shell Model and evidences in support.
- Familiarization with different types of nuclear reactions, Q- values, compound and direct reactions.
- To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter and neutron interaction with matter.
- To understand classification of fundamental forces based on their range, time-scale and mediator mass.
- To understand Scattering cross-sections of 2 to 2 processes and their inherent symmetries.
- Angular and energy distributions for three body decay process.
- Discrete symmetries of nature and associated conservation laws and Colour triplet

SYLLABUS OF DSE 8-6
THEORY COMPONENT
(Hours: 45)

Unit I **(15 Hours)**

General Properties of Nuclei and Nuclear Models: Constituents of nucleus and their Intrinsic properties. Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas). Single Particle Shell Model (Concept of mean field and spin orbit coupling), Estimation of Spin parity and electromagnetic moments for ground state configuration for even- even, even -odd and odd-odd nuclei. Basic concept of Collective Model and deformed shell model.

Unit II **(10 Hours)**

Nuclear Reactions: Types of Reactions, Units of related physical quantities, Conservation Laws, Kinematics of reactions, Q-value, Reaction rate, Reaction cross section, Concept of compound and direct reaction, Coulomb scattering (Rutherford scattering).

Unit III **(8 Hours)**

Interaction of Nuclear Radiation with matter: Interaction of radiation for light ions (electrons) and heavy charge particles, neutron and photons with matter. Energy loss due to ionization (Bethe-Block formula), for both light and heavy-ions, Cerenkov radiation. Gamma ray interaction with matter. Neutron interaction with matter.

Unit IV **(12 Hours)**

Particle Physics: Overview of Particle spectrum and their interactions in the Standard Model. Range, time-scale and relative strength of interactions. Interactions at a distance mediated by virtual particles (Exchange Force).
Requirement of High Energy Colliders to probe the constituents of nucleon, Linear and circular colliders, Inelastic collisions at Hadron colliders. Brief idea about Large Hadron Collider experiment and Indian ALICE and CMS and collaborations.
Kinematics for $2 \rightarrow 2$ scattering processes and Crossing symmetries of scattering amplitudes. Angular and energy distributions of decaying particles in $1 \rightarrow 3$ decay processes (muon decay / beta decay).
Lepton and Baryon quantum numbers. Isospin, Strangeness and Hypercharge. Gell-Mann-Nishijima formula. Parity and Charge conjugation of a particle state. Time Reversal and General CPT theorem.
Valence quark model of Murray Gell-Mann and Yuval Ne'eman, current and constituent masses of quarks, flavor symmetry Isospin triplets, Baryon octet and decuplet, Meson octet. Antisymmetric Δ^{++} state and necessity for color quantum number. Evidence for color triplet quarks from $\mathbf{e^+e^-}$ annihilation experiment.

REFERENCES

Essential Readings

For Nuclear Physics

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2. Introductory Nuclear Physics by K S Krane, Wiley-India Publication, 2008.
3. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
4. Nuclear Physics: principles and applications by J Lilley, Wiley Publication, 2006.
5. Concepts of Nuclear Physics by B L Cohen, Tata McGraw Hill Publication, 1974.
6. Radiation detection and measurement, G F Knoll, John Wiley & Sons, 2010.

For Particle Physics

7. Modern Particle Physics by Mark Thompson, Cambridge University Press, 2013.
8. Particles and Nuclei: An Introduction to the Physical Concepts by Bogdan Povh, Klaus Rith, Christoph Scholz, Frank Zetsche, Werner Rodejohann, Springer-Verlag 2015.
9. An Introductory Course of Particle Physics, Palash B. Pal (CRC Press, 2015)
10. Introduction to High Energy Physics by D H Perkins, 4^{th} edition, Cambridge University Press, 2000.
11. Introduction to elementary particles by D J Griffiths, Wiley, 2008.
12. Quarks & Leptons, F. Halzen and A. D. Martin, John Wiley, 1984.

References for Tutorial

13. Problems and Solutions in Nuclear and Particle Physics by Sergio Petreta, Springer, 2019.
14. Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
15. Schaum's Outline of College Physics, by E. Hecht, 11th edition, McGraw Hill, 2009.
16. Problems and Solutions on Atomic, Nuclear and Particle Physics by Yung-Kuo Lim, World Scientific, 2000.
17. Nuclear Physics "Problem-based Approach" Including MATLAB by Hari M. Aggarwal, PHI Learning Pvt. Ltd. (2016).

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-7 : PLASMA PHYSICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Plasma Physics DSE 8-7	4	3	1	0	

COURSE OBJECTIVES

This course presents the characteristic plasma properties and theoretical approaches to plasma physics. It treats single charged-particle motion in electromagnetic fields, collisions, electrical conductivity and diffusion, and plasma waves. Applications to controlled thermonuclear fusion, plasma processing, and astrophysical plasmas will serve to illustrate when and where the various theories are applicable.

LEARNING OUTCOMES

At the end of the course, the students will be able to:

- define, using fundamental plasma parameters, under what conditions an ionised gas consisting of charged particles (electrons and ions) can be treated as a plasma.
- know various applications of plasma physics.
- determine the drift velocities of charged particles moving in electric and magnetic fields that are either uniform or vary slowly in space and time.
- distinguish the single particle approach, fluid approach to describe different plasma phenomena and formulate the conditions for a plasma to be in a state of perfect thermodynamic equilibrium.
- apply the conservation laws and Maxwell's equations to describe dynamical processes like wave propagation in a plasma.

SYLLABUS OF DSE 8-7
THEORY COMPONENT
(Hours: 45)

Unit I **(12 Hours)**

Introduction to plasma: Basics of gas dynamics, occurrence of plasma in nature, concept of temperature and density of plasma, Saha’s equation, quasineutrality in plasma, collective behaviour, Debye shielding, Microscopic Properties (resistivity and conductivity).

Unit II **(8 Hours)**

Plasma applications and measurement: Gas discharge, industrial plasma, ionosphere plasma, solar plasma, plasma processing of materials, laser ablation, laser-driven fusion, magnetic fusion, plasma propulsion. Basics of Plasma production in laboratory and diagnostics

Unit III **(13 Hours)**

Particle confinement: Single particle motion in the presence of uniform and non-uniform electric and magnetic field, Grad-B drift, curvature drift, polarization drift, Magnetic mirrors and concept of earth magnetic mirror, Basic concept of controlled thermonuclear fusion.

Unit IV **(12 Hours)**

Fluid description of plasma: Set of fluid equations of plasmas, diamagnetic drift of plasma, plasma approximation, waves in cold plasmas, plasma oscillations, electron plasma wave, ion acoustic wave, electromagnetic wave in unmagnetized plasma.

REFERENCES

1. Introduction to Plasma Physics and Controlled Fusion by F. F. Chen (Third Edition 2016).
2. The Physics of Plasmas, by T. J. M. Boyd and J. J. Sanderson. Cambridge University Press, 2003.
3. Introduction to Plasma Physics, R.J. Goldston and P. H. Rutherford (IOP, 1995).
4. Fundamentals of Plasma Physics -J. A. Bittencourt, Springer, New York, NY (Third edition).
5. The physics of fluids and plasmas: an introduction for astrophysicists – Arnab Rai Choudhuri, Cambridge University Press (1998)
6. Principles of Plasma Physics, N.A. Krall and A.W. Trivelpiece, Mc Graw Hill (1973).
7. Principles of Plasma Discharges and Materials Processing (Second Edition, 2005) by Lieberman, Lichtenberg.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-8: SENSORS AND DITECTORS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Sensors and Detectors DSE 8-8	4	3	0	1	

COURSE OBJECTIVES

To make students familiar with the constructions and working principle of different types of sensors and transducers. To make students aware about the measuring instruments and the methods of measurement and the use of different transducers.

LEARNING OUTCOMES

At the end of the course, a student will be able to:

- Use concepts in common methods for converting a physical parameter into an electrical quantity.
- Classify and explain with examples of transducers, including those for measurement of temperature, strain, motion, position and light.
- Choose proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc.
- Predict correctly the expected performance of various sensors.
- Locate different type of sensors used in real life applications and paraphrase their importance.
- Set up testing strategies to evaluate performance characteristics of different types of sensors and transducers and develop professional skills in acquiring and applying the knowledge outside the classroom through design of a real-life instrumentation system.

SYLLABUS OF DSE 8-8
THEORY COMPONENT
(Hours: 45)

Unit I **(13 Hours)**

Transducers, Classification of transducers on different basis, Types of transducers (Basic idea of Mechanical, resistive, capacitive, inductive, piezoelectric, optical and digital).
Sensor, Components of sensor, Direct and complex sensor (Basic idea)
Distinction between Sensor and Transducer, Characteristics of Transducers/Sensor: Static characteristics and static calibration (Calibration accuracy and component error), Dynamic characteristics.
Inductive sensor: Variable Inductance Sensors, Plunger type displacement sensor, Variable Gap Sensor, LVDT: Construction, working, output characteristics. Idea of RVDT (Qualitative). **Capacitive sensors:** Variable distance-parallel plate type, variable area- parallel plate (serrated plate/teeth type), variable dielectric constant type; Sensitivity of capacitive sensors, Stretched diaphragm type

Unit II **(9 Hours)**

Magnetic Sensors: Magnetoresistive Sensors and Hall effect sensor (performance and characteristics).
Temperature sensor: RTD (construction, working and temperature coefficient), thermistor, categories of thermistor (PTC and NTC: material, shape, ranges, RT curve and accuracy specification), Thermo emf sensor (thermoelectricity generation, thermos-emf measurement, Thermocouples (construction, characteristics), and Pyroelectric sensors (pyroelectric effect and output voltage-temperature relationship).

Unit III **(13 Hours)**

Pressure sensors: Direct versus indirect pressure measurement, Different types of gauges and their working range, Mechanical gauges (McLeod Gauge), Thermal Conductivity Gauges (Thermocouple and Pirani gauges) and Ionization gauges (hot & cold cathode), advantages and limitations of various types of gauges, Gauge calibration (Static: Manometric method and dead-beat tester, dynamic calibration).
Radiation Sensors: Basic Characteristics (Concept of Work Function, Spectral Sensitivity, Spectral threshold, Quantum yield, time lag, linearity, Status and dynamic response), Types of Photodetectors: Photoemissive Cell, Photo Multiplier, Photo conductive Cell (LDR), Photovoltaic cells, photodiodes. Detection of Nuclear Radiation: Qualitative treatment of Geiger Muller counters and Scintillation detectors.

Unit IV **(10 Hours)**

Applications of Sensors and detectors: Basic principles of Remote sensing, Introduction to LiDAR (principles, applications and benefits), Types of LiDAR (air-borne and ground based) Applications of motion sensors in accelerometers and gyroscopes (qualitative analysis of working principle).
Biomedical Sensor: Electrochemical sensor (electrochemical cell, cell potential, three electrodes system, working principle).

PRACTICAL COMPONENT: SENSORS AND DETECTORS
(Hours: 30)

At least 5 experiments to be done from the list below:

1. Characteristics of LDR as a function of distance from light source.
2. Light characteristics of Photodiode.
3. Measurement of Strain using Strain Gauge.
4. To study the characteristics of a Linear Variable Differential Transformer (LVDT).
5. To study the characteristics of a Resistance Temperature Device (RTD).
6. To study the frequency response of a loudspeaker.
7. Determine characteristics of an Infrared (IR) emitter-receiver module.
8. Create vacuum in a small chamber using a mechanical (rotary) pump and/or secondary pump and measure the chamber pressure using a pressure gauge – Pirani and/or CC gauge.
9. Measurement of thermos-emf in thermopile and to calculate the Seebeck coefficient.
10. Study the pyroelectric effect and generation of induced voltage with temperature change.

REFERENCES

Essential Readings for the Theory Component

1. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
2. Introduction to Measurements and Instrumentation, A.K. Ghosh, PHI Learning Pvt. Ltd.
3. 3.Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
4. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata
5. McGraw Hill
6. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer
7. Electronic Instrumentation by H. S. Kalsi (Mc Graw Hill Publisher)
8. Sensors and Transducers, D Patranabis, PHI Learning Pvt. Ltd.
9. An Introduction to Sensors and Instrumentations, Sobnath Singh, Narosa
10. Handbook of Modern Sensors, Jacob Fraden, Springer
11. Handbook of Thion film Technology, Maissel and Glang, Tata McGraw Hill
12. Instrumentation, Measurement and Analysis, Nakra and Chaudhry, McGraw Hill

Additional Readings for the Theory Component

1. Radiation detection and measurement, G.F. Knoll, Wiley
2. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M.Sayer and A. Mansingh, PHI

References for the Practical Component

1. Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, Springer
2. Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino, M. A. Miller, McGraw

SKILL BASED COURSE – SBC 8-1: INTERFACING WITH ARDUINO

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Interfacing with Arduino SBC 8-1	2	0	0	2	SBC 7-1: Arduino Programming

COURSE OBJECTIVES

- Explain the architecture and features of the Arduino Platform.
- Set up and use the Arduino IDE to write, debug, and upload code to an Arduino board.
- Write basic programs involving digital and analog I/O, loops, functions, and conditional statements.
- Implement simple tasks such as blinking LEDs, reading buttons, generating PWM signals, and reading analog voltages.
- Understand serial communication and use the Serial Monitor for debugging.
- Design small-scale automation and control programs using Arduino logic.

LEARNING OUTCOMES

- Identify and describe the working principles of common sensors (e.g., temperature, light, distance) and actuators (e.g., motors, buzzers).
- Interface sensors (LDR, DHT11, ultrasonic, IR, etc.) with Arduino and acquire data.
- Control actuators (relays, DC motors, stepper motors, servos, buzzers) using digital output and PWM.
- Design simple projects such as automatic lighting systems, object detection alarms, or temperature monitors.
- Implement basic feedback and control systems (e.g., temperature-based fan control).
- Troubleshoot common hardware and communication issues in Arduino circuits.

SYLLABUS OF SBC 8-1
(Hours: 60)

Apart from common experiments for all students on the listed topics, project-based learning (group activities) to be encouraged.

Unit I **(24 Hours)**

Interfacing with Sensors and Actuators

- Working with Sensors: Introduction to sensors (temperature, humidity, light, magnetic field etc.). Reading analog values.
- Analog and Digital Inputs/Outputs: Analog vs. Digital signals. Working with potentiometers, photoresistors, and thermistors.
- Interfacing with Motors: Controlling DC motors. Introduction to servos and stepper motors.
- Using Displays and Keypads: Interfacing with 7-segment displays and LCDs. Using keypads for input.
- Sound and Audio Output: Working with buzzers and speakers. Generating sound with Arduino.

Unit II **(36 Hours)**

Communication Protocols and Advanced Topics.

- Serial Communication: Understanding UART and Serial Communication. Communication between Arduino and computer.
- I2C and SPI Communication: Introduction to I2C and SPI protocols. Interfacing with external modules (e.g., sensors, displays).
- Wireless Communication: Introduction to wireless modules (Bluetooth, Wi-Fi). Simple projects using wireless communication.
- Data Logging: Reading and storing data from sensors. SD card modules and data logging projects.
- Introduction to IoT with Arduino: Basics of the Internet of Things (IoT). Simple IoT project: Sending data to a web server.
- Planning and designing your project.

SUGGESTED READINGS

"Getting Started With Arduino" By Massimo Banzi and Michael Shiloh. Shroff/Maker Media; fourth edition (2022). ISBN-13 : 978-9391043858

B.Sc. Physical Sciences with Physics as one of the Core Disciplines

SKILL BASED COURSE – SBC 8-2: WEATHER FORECASTING

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Weather forecasting SBC 8-2	2	1	0	1	

COURSE OBJECTIVES

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques.

LEARNING OUTCOMES

The student will gain the following:

- Acquire basic knowledge of the elements of the atmosphere, its composition at various heights, variation of pressure and temperature with height.
- Learn basic techniques to measure temperature and its relation with cyclones and anti-cyclones.
- Knowledge of simple techniques to measure wind speed and its directions, humidity and rainfall.
- Understanding of absorption, emission and scattering of radiations in atmosphere; Radiation laws.
- Knowledge of global wind systems, jet streams, local thunderstorms, tropical cyclones, tornadoes and hurricanes.
- Knowledge of climate and its classification. Understanding various causes of climate change like global warming, air pollution, aerosols, ozone depletion, acid rain.
- Develop skills needed for weather forecasting, mathematical simulations, weather forecasting methods, types of weather forecasting, role of satellite observations in weather forecasting, weather maps etc. Uncertainties in predicting weather based on statistical analysis.
- Develop ability to do weather forecasts using input data.
- In the laboratory course, students should be able to learn: Principle of the working of a weather Station, Study of Synoptic charts and weather reports, Processing and analysis of weather data, Reading of Pressure charts, Surface charts, Wind charts and their analysis.

SYLLABUS OF SBC 8-2
THEORY COMPONENT
(Hours: 15)

Unit -1 **(8 Periods)**

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.

Unit-2 **(7 Periods)**

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution and its measurement, particulate matters PM 2.5, PM 10. Health hazards due to high concentration of PM2.5; aerosols, ozone depletion.

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

PRACTICAL COMPONENT: WEATHER FORECASTING
(Hours: 30)

Demonstrations and Experiments:

1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
   (a) To calculate the sunniest time of the year.
   (b) To study the variation of rainfall amount and intensity in different seasons.
   (c) To examine the maximum and minimum temperature throughout the year.
   (d) To study the relative humidity of the day and seasons and the entire year.
   (e) Development and movement of low and high Pressure system over Indian/global region.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and non-aviation).
5. Simulation of weather system

6. Field visits to India Meteorological department and National center for medium range weather forecasting

REFERENCES

Essential Readings

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
4. Text Book of Agro meteorology, S.R. Ghadekar, 2005,Agromet Publishers, Nagpur.
5. Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

Additional Reading:

1. PM2.5 diminution and haze events over Delhi during the COVID-19 lockdown period: an interplay between the baseline pollution and meteorology, Nature- Scientific Reports, 10(13442). https://doi.org/10.1038/s41598- 020-70179-8., S. K. Dhaka, Chetna, V. Kumar, V. Panwar, A. P. Dimri, N. Singh, P. K. Patra, Y. Matsumi, M. Takigawa, and T. Nakayama (2020)
2. Chapter 1 - Composition and thermal structure of the earth's atmosphere, Atmospheric Remote Sensing, Principles and Applications, Earth Observation, 2023, Pages 1-18, https://doi.org/10.1016/B978-0-323-99262-6.00023-7. SK Dhaka and Vinay Kumar.
3. Climatic trends in temperature, relative humidity, and wind speed over Indian landmass and isle in Andaman Nicobar and Lakshadweep during 1981-2021, MAPAN-Journal of Metrology Society of India, (2024), DOI: 10.1007/s12647-024-00743-4, Shristy Malik, A.S. Rao, S K. Dhaka.
4. Decoding temporal patterns and trends of PM10 pollution over Delhi: A multi-year analysis (2015–2022). Environmental Monitoring and Assessment, 196(6), 500. https://doi.org/10.1007/s10661-024-12638-7, Chetna, Dhaka, S. K., Walker, S.-E., Rawat, V., & Singh, N. (2024).

DEPARTMENT OF PHYSICS AND ASTROPHYSICS

Undergraduate Curriculum Framework 2022

B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

FOR MAJOR IN ELECTRONICS

Semesters VII and VIII

Note:

1. Here,

   DSC: Discipline Specific Core
   DSE: Discipline Specific Elective
   SBC: Skill-based Course

1. * Research Methodology is the same as notified as a DSE for Sem VI (DU Notification dated 16.5.2024).

2. ** Are SEC notified on 28.3.2023.

3. Students should ensure that they do not repeat a SEC course as SBC.

4. As it is NOT permissible to choose courses having similarity of the content to the tune of 30% or more, students should ensure that while opting DSEs.

B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – DSC 7-1: ELECTROMAGNETIC THEORY

Course Title and Code	Credits	Credit Distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Electromagnetic Theory DSC 7-1	4	3	0	1	

COURSE OBJECTIVES

This core course develops further the concepts learnt in the electricity and magnetism course to understand the properties of electromagnetic waves in vacuum and different media.

LEARNING OUTCOMES

At the end of this course the student will be able to,

- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density
- Understand electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma
- Understand electromagnetic wave propagation in bounded media: reflection and transmission coefficients at plane interface in bounded media
- Understand polarization of electromagnetic waves: Linear, circular and elliptical polarization. Production as well as detection of waves in laboratory
- Learn the features of planar optical wave guide
- In the laboratory course, the students will get an opportunity to perform experiments with polarimeter, Babinet compensator, ultrasonic grating and simple dipole antenna. Also, to study phenomena of interference, refraction, diffraction and polarization

SYLLABUS OF DSC 7-1
THEORY COMPONENT
(Hours: 45)

Unit – I **(6 Hours)**

Review of Maxwell's equations; Coulomb gauge and Lorentz gauge; Poynting's theorem and Poynting's vector; electromagnetic (em) energy density; physical concept of electromagnetic field energy density

Unit – II **(19 Hours)**

EM wave propagation in unbounded media: Plane em waves through vacuum and isotropic dielectric medium: transverse nature, refractive index, dielectric constant, wave impedance. Plane em waves through conducting medium: relaxation time, skin depth, attenuation constant; Wave propagation through dilute plasma: electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth.
EM waves in bounded media: Boundary conditions at a plane interface between two media; reflection and refraction of plane em waves at plane interface between two dielectric media - Laws of reflection and refraction; Fresnel's formulae for perpendicular and parallel polarization, Brewster's law; reflection and transmission coefficients; total internal reflection, evanescent waves; metallic reflection (normal incidence).

Unit – III **(13 Hours)**

Polarization of EM waves: Propagation of em waves in an anisotropic media; symmetric nature of dielectric tensor; Fresnel's formula; uniaxial and biaxial crystals; light propagation in uniaxial crystal; double refraction; polarization by double refraction; Nicol prism; ordinary and extraordinary refractive indices; production and detection of plane, circular and elliptically polarized light; phase retardation plates: quarter wave and half wave plates.
Optical rotation; Biot's laws for rotatory polarization; Fresnel's theory of optical rotation; specific rotation

Unit – IV **(7 Hours)**

Wave guides: Planar optical wave guides; planar dielectric wave guide ($-d/2 < x < d/2$); condition of continuity at interface; phase shift on total reflection; Eigenvalue equations; phase and group velocity of guided waves; field energy and power transmission (TE mode only)

PRACTICAL COMPONENT: ELECTROMAGNETIC THEORY

(Hours: 30)

- Mandatory sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.
- Mandatory sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.

At least six experiments to be performed from the following list

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using polarimeter.
3. To analyse elliptically polarized light by using a Babinet's compensator.
4. To study the elliptical polarized light using Fresnel rhomb.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection and refraction of microwaves
7. To study polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To verify the Stefan's law of radiation and to determine Stefan's constant.
11. To determine Boltzmann constant using V-I characteristics of PN junction diode.
12. To find numerical aperture of an optical fibre.
13. To use a prism shaped double refracting crystal to determine the refractive indices of the quartz/ calcite corresponding to ordinary and extra-ordinary rays.
14. To measure birefringence of Mica
15. To determine the dielectric constant of solids using microwaves

REFERENCES

Essential Readings for the Theory Component

1) Introduction to Electrodynamics, D. J. Griffiths, 3rd edition, 1998, Benjamin Cummings.
2) Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd edition, 2003, CBS Publisher
3) Classical Electrodynamics, J. D. Jackson, 3rd edition, 2010, Wiley
4) Principle of Optics, M. Born and E. Wolf, 6th edition, 1980, Pergamon Press
5) Optics, A. Ghatak, 6th edition, 2017, McGraw-Hill Education, New Delhi

Additional Readings for Theory Component

1) Electricity, Magnetism and Electromagnetic Theory, S. Mahajan, and S. R. Choudhary, 2017, TMH
2) Principles of Electromagnetic Theory, C. Jain, 2017, Narosa Publishing House
3) Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
4) Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill
5) Problems and solution in Electromagnetics, A. Ghatak, K. Thyagarajan and Ravi Varshney, 2015
6) Electromagnetic field Theory, R. S. Kshetrimayun, 2012, Cengage Learning
7) Engineering Electromagnetic, W. H. Hayt, 8th edition, 2012, McGraw Hill.
8) Electromagnetics, J. A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
9) 2008+ Solved Problems in Electromagnetics, S. A. Nasar, 2001, SciTech

References for the Laboratory Work

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publisher
3) Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
4) Practical Physics, G. L. Squires, 4th edition, 2015, Cambridge University Press
5) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd

B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7-1: NUMERICAL ANALYSIS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Numerical Analysis DSE 7-1	4	2	0	2	

COURSE OBJECTIVES

The main objective of this course is to introduce the students to the field of numerical analysis, enabling them to solve a wide range of physics problems. The skills developed during the course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will be able to,

- Analyse a physics problem, establish the mathematical model and determine the appropriate numerical techniques to solve it.
- Derive numerical methods for various mathematical tasks such as solution of non-linear algebraic and transcendental equations, system of linear equations, interpolation, least square fitting, numerical differentiation, numerical integration, eigen value problems and solution of initial value and boundary value problems.
- Analyse and evaluate the accuracy of the numerical methods learned.
- In the laboratory course, the students will learn to implement these numerical methods in Python/C++/Scilab and develop codes to solve various physics problems and analyze the results.

<u>SYLLABUS OF DSE 7-1</u>
<u>THEORY COMPONENT</u>
(Hours: 30)

Unit I **(3 Hours)**

Approximation and Errors in computing: Introduction to numerical computation, Taylor's expansion and mean value theorem. Floating Point Computation, overflow and underflow. Single and double precision arithmetic. Rounding and truncation error, absolute and relative error, error propagation.

Unit II **(8 Hours)**

Linear Systems: Solution of linear systems by Gaussian elimination method, partial and complete pivoting, LU decomposition, norms and errors, condition numbers, Gauss-Seidel method, diagonally dominant matrix and convergence of iteration methods. Solution of Tridiagonal systems; Eigenvalue Problem: Power method, inverse power method.

Unit III **(12 Hours)**

Interpolation: Lagrange and Newton's methods (divided difference) for polynomial interpolation, theoretical error of interpolation. Inverse Interpolation. Optimal points for interpolation and Chebyshev Polynomials. Minimax Theorem (Statement only). Numerical Integration: Newton Cotes quadrature methods. Derivation of Trapezoidal and Simpson (1/3 and 3/8) rules from Lagrange interpolating polynomial. Error and degree of precision of a quadrature formula. Composite formulae for Trapezoidal and Simpson methods.
Gauss Quadrature methods. Legendre, Lagaurre and Hermite quadrature methods.

Unit IV **(7 Hours)**

Initial and Boundary Value Problems: Solution of initial value problems by Euler, modified Euler and Runge Kutta (RK) methods. Local and global errors, comparison of errors in the Euler and RK methods.
Finite difference and shooting method for solving two-point linear boundary value problems.

<u>PRACTICAL COMPONENT: NUMERICAL ANALYSIS</u>
(Hours: 60)

The aim of this lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics. Assessment is to be done not only on the programming but also on the basis of formulating the problem. The list of recommended programs is suggestive only. Students should be encouraged to do more physics applications. Emphasis should be given to formulate a physics problem as mathematical one and solve by computational methods. The students should be encouraged to develop and present an independent project. At least 10 programs must be attempted (taking at least two from each topics). The implementation can be either in Python/ C++/Scilab.

Linear Systems

a) Solve a system of linear equations using Gauss Elimination method with pivoting (application to electric networks).
b) Solve a system of linear equations using Gauss-Seidel method and study the convergence (application to spring mass system).
c) Determine the inverse of a square matrix using Gauss-Jordan method.
d) Solve a tri-diagonal system of linear equations.
e) Study an example of ill-conditioned systematic
f) Find the LU equivalent of a matrix.
g) Determine the largest and smallest eigenvalues using Power and inverse power methods. Consider a case where power method fails.

Interpolation

a) Given a dataset (x, y) with equidistant x values, prepare the Newton's forward difference, backward difference and divided difference tables.
b) Given a dataset (x, y) corresponding to a physics problem, use Lagrange and Newton's forms of interpolating polynomials and compare. Determine the value of y at an intermediate value of x not included in the data set. This may be done with equally spaced and non-equally spaced x-values.
c) Given a tabulated data for an elementary function, approximate it by a polynomial and compare with the true function.
d) Compare the interpolating polynomial for a given dataset (following a known form e.g. exponential) with the approximation obtained by least square fitting.
e) Compare the interpolating polynomial approximating a given function in a given range obtained with uniformly spaced points and by Chebyshev points.
f) Compare the Chebyshev and Maclaurin series expansions of an exponential or sinusoidal function.

Integration

a) Use integral definition of error function to compute and plot erf(x) in a given range. Use Trapezoidal, Simpson and Gauss Legendre methods and compare the results for small and large values of x.
b) Use the definition of erf(x) and numerically take the limit x going to infinity to get the value of Gaussian integral using Simpson method. Compare the result with the value obtained by Gauss Hermite and Gauss Lagaurre methods.
c) Verify the degree of precision of each quadrature rule.
d) Use Simpson methods to compute a double integral over a rectangular region.

Initial Value Problems (IVP)

a) Compare the errors in Euler, RK2 and RK4 by solving a first order IVP with known solution. Reduce the step size to a point where the round off errors takes over.
b) Solve a system of n first order differential equations by Euler and RK methods. Use it to solve an nth order IVP. Solve a damped free and forced harmonic oscillator problem using this.
c) Solve a physics problem like free fall with air drag or parachte problem using

RK method.

d) Solve a compound spring system (3 springs) by solving a system of differential equations using Euler and RK for a given set of i1nitial conditions.
e) Obtain the current flowing in a series LCR circuit with constant voltage for a given set of initial conditions.

Boundary value problems (BVP)

a) Solve a linear BVP using shooting and finite difference method and compare the results.
b) Solve a non-linear BVP using the finite difference and shooting method and compare the results.
c) Determine the temperature distribution along a rod made of two dissimilar materials (of different thermal conductivities) welded together when temperatures at two ends are maintained at given temperatures.
d) Design a physics problem that can be modelled by a BVP and solve it by any method.

REFERENCES

Essential Readings for Theory Component

1) Applied numerical analysis, Cutis F. Gerald and P. O. Wheatley, Pearson Education, India, 2007
2) Advanced Engineering Mathematics, Erwin Kreyszig, Wiley India, 2008
3) Introduction to Numerical Analysis, S. S. Sastry, 5th Edition, PHI Learning Pvt. Ltd, 2012
4) Elementary Numerical Analysis, K. E. Atkinson, 3rd Edition, Wiley India Edition, 2007

Additional Readings for Theory Component

1) Numerical Recipes: The art of scientific computing, William H. Press, Saul A. Teukolsky and William Vetterling, Cambridge University Press; 3rd Edition, 2007
2) Numerical methods for scientific and engineering computation, M. K. Jain, S. R. K. Iyenge

References for Laboratory Work

1) Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).
2) Documentation of NumPy and Matplotlib: https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/
3) Computational Physics, Darren Walker, 1st Edition, Scientific International Pvt. Ltd, 2015
4) An Introduction to Computational Physics, T. Pang, Cambridge University Press, 2010
5) Computational Problems for Physics, R. H. Landau and M. J. Páez, CRC Press, 201

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DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7-2: PHYSICS OF MATERIALS

Course Title & Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Physics of Materials DSE 7-2	4	2	0	2	

COURSE OBJECTIVES

This course intends to provide knowledge of emerging topics in condensed matter physics. In addition, this course aims to provide a general introduction to advanced topics by covering polymers, liquid crystals, carbon-based materials, and Diluted Magnetic Semiconductors. More importantly, the students will be exposed to different characterization techniques used in experimental condensed matter physics.

LEARNING OUTCOMES

After completion of this course the students should be able to

- Identify different materials of technological importance in appliances and objects around us
- Explain the importance of concepts like density of states and its role in determining device characteristics
- Elucidate the ferroelectric, piezoelectric and pyroelectric materials and their applications.
- Explain the properties of liquid crystals and their application.
- Differentiate between different forms of carbon based materials and their applications
- Introduce the importance of dilute magnetic semiconductors as a new technologically advance material for electronic devices
- Explain various characterisation techniques used in understanding properties of different material

SYLLABUS OF DSE 7-2
THEORY COMPONENT
(Hours: 30)

Unit I **(4 Hours)**

Semiconductors
Basic concept of mobility and conductivity, density of states, determination of electron and hole concentration in doped semiconductor, Fermi level, Fermi energy, Fermi temperature, Fermi wavelength, Fermi surface.

Unit II **(9 Hours)**

Dielectric and magnetic materials
Dielectrics, Ferroelectric, Piezoelectric and Pyroelectric materials, applications of ferroelectrics in capacitors and memory device, Piezoelectrics in micro positioner and actuator, Pyroelectrics in radiation detectors and thermometry. Classification and applications of soft and hard magnetic materials, application in transformers, memory device, introduction of spintronics based systems (spin transport)

Unit III **(9 Hours)**

Polymers, Liquid crystals, Carbon based materials
Polymers: Chemical structure of polymers of few thermoplastic (polyethylene, PVC, PTFE, PMMA, Polyester, Nylons) and thermosetting (Epoxy resin) polymers, conducting polymers- application in organic electronics
Liquid crystals: Classification of liquid crystals, structural and orientational ordering (isotropic to Nematic), thermotropic liquid crystals, Phases and phase transitions; anisotropic; Birefringence and display devices
Carbon based materials: Structure and properties of Fullerenes, C_{60}, single walled and multi walled CNTs, Graphene and their energy band diagram.

Unit IV **(8 Hours)**

Synthesis of materials
Ceramic (Calcination, Sintering, Grain), thin films (general idea of vacuum, thermal evaporation, molecular beam epitaxy, pulsed laser deposition), Crystals (qualitative idea of zone refining and Czochralski method), Polymers (Polymerization mechanism).

PRACTICAL COMPONENT: PHYSICS OF MATERIALS

(Hours: 60)

At least six experiments to be performed from the following list

1. Study phase transition in a ferroelectric sample by measuring its dielectric constant as a function of frequency and temperature.
2. Study dielectric properties of given polymer sample as a function of frequency and temperature.
3. Study dielectric properties of given piezoelectric sample as a function of frequency and temperature.
4. Determine the coupling coefficient of a given piezoelectric crystal.
5. BH Hysteresis of different ferromagnetic materials (Loop Tracer).
6. Analyse the XRD spectra of a given ferroelectric ceramic sample and determine its lattice parameter.
7. Analyse the XRD spectra of a given ferromagnetic sample (basically ferrites, Fe_3O_4, $CoFe_2O_3$) and determine its lattice parameter.
8. Analyse the XRD spectra of a given compound semiconductor (ZnO, TiO_2, etc) thin film/ceramic sample and determine its lattice parameter.
9. Analyse the UV-Vis spectra of a given wide band gap semiconductor and determine its bandgap.
10. Study the IV characteristics of a polymer material by depositing/painting Aluminum electrodes.
11. To determine the g-factor of a sample by ESR Spectrometer.
12. Analyse the given SEM/TEM/AFM micrographs of the deposited thin film or nanostructure of any material and determine surface roughness, crystallinity, particle size etc.
13. Deposition of any kind of thin film by any technique available in the lab.
14. Liquid crystals (reading project)

REFERENCES

Essential readings for the Theory Component

1. Solid State Physics, M. A. Wahab, 2011, Narosa Publishing House
2. Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
3. Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd edition, 2002, Wiley India
4. Introduction to Polymer Physics, U. Eisele and S. D. Pask, 1990, Springer-Verlag
5. The physics of liquid crystals, Pierre-Gilles de Gennes, 2nd edition, 2003, Oxford University Press
6. Introduction to Liquid Crystals, P. J. Wojtowicz, E. Priestly and P. Sheng, 1975, Plenum Press
7. Dielectric Phenomenon in solids with Emphasis on Physical Concepts of Electronic Processes, K. C. Kao, Elsevier.
8. Physics of Ferroelectrics A Modern Perspective, K. M. Rabe Charles H. Ahn Jean-

Marc Triscone, Springer
9. Carbon Nanotubes: Properties and Applications, M. J. O’Connell, 2006, CRC Press
10. Dilute Magnetic Semiconductors, M. Jain, World Scientific.

Additional readings for the Theory Component

1. Encyclopaedia of materials characterization: surfaces, interfaces, thin films, R. C. Brundle et al., 1992, Butterworth-Heinemann
2. Physical Methods for Materials Characterization, P. E. J. Flewitt, R. K. Wild, (2nd Ed., CRC Press, 2015).
3. Dilute magnetic semiconducting materials, Br. R. Saravanan, MRF

References for the Laboratory Work

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11^{th} edition, 2011, Kitab Mahal
3. Elements of Solid State Physics, J. P. Srivastava, 2^{nd} edition, 2006, Prentice-Hall of India
4. Elements of X-Ray Diffraction, B. D. Cullity and S. R. Stock
5. Physical Methods for Materials Characterization, P. E. J. Flewitt, R. K. Wild, 2^{nd} edition, 2015, CRC Press
6. Encyclopedia of materials characterization: surfaces, interfaces, thin films, R. C. Brundle et al., 1992, Butterworth-Heinemann

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DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7 - 3 : QUANTUM MECHANICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Quantum Mechanics DSE 7-3	4	3	1	0	

COURSE OBJECTIVES

The development of quantum mechanics has revolutionized human life. In this course, students will be exposed to the probabilistic concepts of basic non-relativistic quantum mechanics and its applications to understand the subatomic world.

LEARNING OUTCOMES

After completing this course, the students will be able to

- Solve Schrödinger equation for different 1-d potentials, such as finite square potential well, potential steps and barriers and distinguish between scattering and bound states.
- Use the algebraic method to solve the Schrödinger equation for quantum harmonic
- Solve the 3-D Schrodinger equation in spherical coordinates.
- Understand the spectrum and eigenfunctions for hydrogen atom
- Understand the angular momentum operators in position space, their commutators, eigenvalues and eigenfunctions.
- Explain the concept of spin, use Pauli matrices to describe spin-½ systems, and construct the singlet and triplet spin states for two-particle systems.

<u>SYLLABUS OF DSE 7-3</u>
<u>THEORY COMPONENTS</u>
(Hours: 45)

Unit I **(20 Hours)**

Schrödinger Equation for 1- dimensional systems
General solution of 1-D Schrödinger equation for time independent potentials, Solution of Schrödinger equation for a particle in a finite square potential well, reflection and transmission across a step potential and a rectangular potential barrier.
General discussion of bound states in an arbitrary potential: Continuity of wave function, boundary conditions and emergence of discrete energy levels with Application to energy eigenstates for a particle in a finite square potential well.
Momentum space wavefunction, Time evolution of Gaussian Wave packet, Superposition Principle, linearity of Schrodinger Equation, General solution as a linear combination of discrete stationary states, Observables as operators, Commutator of position and momentum operators, Ehrenfest's theorem.
Harmonic oscillator
Energy eigenvalues and eigenstates of a 1-D harmonic oscillator using the algebraic method (ladder operators). Zero-point energy and the uncertainty principle.

Unit II **(12 Hours)**

Schrödinger Equation in three dimensions
Probability and probability densities in 3D. Schrödinger equation in spherical polar coordinates, its solution for the Hydrogen atom solution using separation of angular and radial variables. Solution of angular equation, Spherical harmonics.
Solution of radial equation using Frobenius method, Radial wavefunctions, Probability densities for ground and first excited states, quantum numbers n, l and ml.

Unit III **(7 Hours)**

Angular Momentum: Orbital Angular momentum operators (**Lx**, **Ly** and **Lz**) and ladder operators **L+** and **L-** as differential operators in cartesian coordinates and their commutation relations, Orbital angular momentum operators in spherical polar coordinates, their eigenvalues, eigenfunctions and identification of these with spherical harmonics.

Unit IV **(6 Hours)**

Concept of spin: Spin angular Momentum Operator, Pauli matrices, algebraic theory of spin, General state for spin-1/2 particles, Total spin for a system of two spin-1/2 particles, singlet and triplet states.

REFERENCES

Essential Readings

1. Quantum Mechanics: Theory and Applications, Ajoy Ghatak and S. Lokanathan, Laxmi Publications (2019).
2. Introduction to Quantum Mechanics, D.J. Griffith, Pearson Education (2005).
3. A Textbook of Quantum Mechanics, P.M. Mathews and K. Venkatesan, McGraw-Hill (2010).
4. Quantum Mechanics, B. H. Bransden and C. J. Joachain, Prentice Hall (2000).
5. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, John Wiley and Sons, Ltd. (2009).

Additional Readings

1. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, Cambridge University Press (2008).
2. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications (1966).
3. Quantum Mechanics, Leonard I. Schiff, Tata McGraw Hill (2010).
4. Quantum Mechanics, Robert Eisberg and Robert Resnick, Wiley (2002).
5. Schaum's Outlines of Quantum Mechanics, Yoav Peleg, Reuven Pnini, Elyahu Zaarur, Eugene Hecht, NcGrawHill (2010).
6. Introductory Quantum Mechanics, R. L. Liboff; 4th Ed., Addison Wesley (2003).

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DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7 - 4 : VERY LARGE SCALE INTEGRATED CIRCUIT DESIGN

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Very Large Scale Integrated Circuit Design DSE 7-4	4	3	0	1	

COURSE OBJECTIVES

The paper discusses basic principle of MOS Transistor operation for digital design, SPICE model, MOS transistor and Inverter layout, CMOS layout. Inverter design, CMOS inverter, inverter characteristics and specifications. MOS Logic design, pass transistor logic, static & dynamic latches, flip flops, static & dynamic registers.

LEARNING OUTCOMES

At the end of this course, students will be able to

1. Understand the concept of models of MOS devices and their implementation in designing of CMOS inverter.
2. Measure the performance parameters like threshold voltage, noise margins, time delays etc.
3. Familiarize with the techniques and components involved in combinational MOS circuit designs.

SYLLABUS OF DSE 7-4

THEORY COMPONENTS

(Hours: 45)

Unit I **(10 Hours)**
Metal Oxide Semiconductor (MOS)
Introduction to basic principle of MOS transistor, large signal MOS models (long channel) for digital design.

Unit II **(10 Hours)**
MOS SPICE model, MOS device layout
Integrated circuit technology- SSI, MSI, LSI, VLSI, Transistor layout, Inverter layout, CMOS digital circuit layout.

Unit III **(15 Hours)**

MOS Inverter

Inverter principle, Depletion and enhancement load inverters, the basic CMOS inverter, transfer characteristics, logic threshold, Noise margins, Propagation Delay and Power Consumption.

Unit IV **(10 Hours)**

Combinational MOS Logic Design

Static MOS design, Pass Transistor logic, complex logic circuits. Sequential MOS Logic Design - Static latches, Flip flops & Registers

PRACTICAL COMPONENT: VERY LARGE SCALE INTEGRATED CIRCUIT DESIGN

(Hours: 30)

Basic VLSI Design Lab (PSpice/Similar Simulation software)

Students should perform at least four practicals from the following list:

1. To plot the (i) output characteristics & (ii) transfer characteristics of an n-channel and p-channel MOSFET.
2. To design and plot the static (VTC) and dynamic characteristics of a digital CMOS inverter.
3. To design and plot the output characteristics of a 3-inverter ring oscillator.
4. To design and plot the dynamic characteristics of 2-input NAND, NOR, XOR and XNOR logic gates using CMOS technology.
5. To design and plot the characteristics of a 4x1 digital multiplexer using pass-transistor logic.
6. To design and plot the characteristics of a positive and negative latch based on multiplexers.
7. To design and plot the characteristics of a master-slave positive and negative edge triggered registers based on multiplexers

REFERENCES

1. Kang & Leblebigi ―CMOS Digital IC Circuit Analysis & Design‖- McGraw Hill, 2003.
2. Rabey, ―Digital Integrated Circuits Design‖, Pearson Education, Second Edition, 2003.
3. Weste and Eshraghian, ―Principles of CMOS VLSI design‖ Addison-Wesley, 2002.
4. Basic VLSI design: Douglas A Pucknell, Kamran Eshraghian, PHI, 3rd edition

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SKILL BASED COURSE – SBC 7-1:
ARDUINO PROGRAMMING

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Arduino Programming SBC 7-1	2	0	0	2	

COURSE OBJECTIVES

- To introduce students to the fundamentals of embedded systems using the Arduino platform.
- To develop programming skills in C/C++ for microcontroller-based applications.
- To foster logical thinking and problem-solving through real-world electronic projects.
- To lay the foundation for interfacing sensors and actuators using digital and analog I/O.

LEARNING OUTCOMES

- Explain the architecture and features of the Arduino Platform.
- Set up and use the Arduino IDE to write, debug using Serial Monitor, and upload code to an Arduino board.
- Write basic programs involving digital and analog I/O, loops, functions, and conditional statements.
- Implement simple tasks such as blinking LEDs, reading buttons, generating PWM signals, and reading analog voltages.
- Understand serial communication and use the Serial Monitor for debugging.
- Design small-scale automation and control programs using Arduino logic.

SYLLABUS OF SBC 7-1
(Hours: 60)

Unit I **(24 Hours)**

Introduction to Arduino

- Overview of Arduino and its applications.
- Understanding microcontrollers and development boards.

- Introduction to the Arduino IDE.
- Installing the Arduino IDE.
- Connecting Arduino to your computer.
- First program: Blink an LED (Hello World of Arduino).

Basic Electronic Components

- Basic concepts of electronic components- Resistors, capacitors, diodes, transistors, LEDs.
- Breadboards and prototyping techniques.
- Ohm's Law and calculating resistor values for LEDs.
- Controlling LEDs with Arduino.
- Switches and Buttons: Digital inputs and outputs. Using push buttons with Arduino.

Unit II **(36 Hours)**

Programming Fundamentals

- Arduino Programming Basics: Structure of an Arduino sketch (setup and loop functions), Variables, data types, and operators.
- Control Structures: Conditional statements (if, else, switch). Loops (for, while, do-while).
- Functions and Libraries: Writing and using functions. Introduction to Arduino libraries.
- Debugging and Troubleshooting: Common errors and debugging techniques. Serial communication (Serial Monitor) for debugging.

List of Experiments

1. Blink an LED. Also modify blink rate.
2. Button-Controlled LED. Turn an LED on/off using a push button.
3. Debounce a Button. Implement debounce to handle noisy button presses.
4. LED Fading to control LED brightness.
5. Potentiometer-Controlled LED. Adjust LED brightness using potentiometer and analog Read().
6. Serial Monitor Interaction. Display text and sensor readings on the Serial Monitor.
   16x2 LCD Display. Display "Hello, World!" and temperature data.

Project-based learning to be encouraged.

SUGGESTED READINGS

"Getting Started With Arduino" By Massimo Banzi and Michael Shiloh. Shroff/Maker Media; fourth edition (2022). ISBN-13 : 978-9391043858

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DISCIPLINE SPECIFIC CORE COURSE – DSC 8-1: DIGITAL AND OPTICAL COMMUNICATION

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Digital and Optical Communication DSC 8-1	4	3	0	1	

COURSE OBJECTIVES

This course aims to provide students with a comprehensive understanding of the principles and applications of digital and optical communication systems. It covers the fundamentals of signal processing, various digital modulation techniques, and the operation of optical communication components such as lasers, LEDs, and photodetectors. The course also introduces the characterization of optical fibers and addresses key performance parameters such as noise, signal-to-noise ratio, and bit error rate.

LEARNING OUTCOMES

By the end of the course, students will be able to:

- Explain the principles of sampling, multiplexing, and the statistical behavior of random processes in communication systems.
- Describe and analyze various digital modulation schemes including ASK, FSK, PSK, QPSK, QAM, and M-ary coding techniques.
- Understand the working and characteristics of optical sources and detectors used in fiber-optic communication, such as laser diodes, LEDs, and photodiodes.
- Evaluate the characteristics and performance of optical fibers, including measurements of core radius, numerical aperture, and cut-off wavelength.
- Assess the impact of noise and signal degradation on communication performance, including calculation of SNR and BER in digital and optical systems.

SYLLABUS of DSC 8-1
THEORY COMPONENT
(Hours: 45)

Unit I **(8 Hours)**
An overview of sampling theorem and multiplexing (digital Systems)
Random processes, stationary processes, mean, correlation, and covariance functions: autocorrelation function, cross-correlation function, Power spectral density

Unit II **(11 Hours)**

Digital Modulation Schemes: ASK (Amplitude Shift Keying), FSK (Frequency Shift Keying), PSK (Phase Shift Keying), DPSK(Differential Phase Shift Keying), QPSK (Quadrature Phase Shift Keying), QAM(Quadrature Amplitude Modulation), M-ary coding.

Unit III **(15 Hours)**

Sources and detectors for optical fibre communication: Optical Communication requirements, LASER fundamentals: Absorption and emission of radiation, condition for amplification of radiation. Basics of semiconductor lasers, laser diode characteristics, LED characteristics. Principle of optical detection, PIN photodetector, responsivity and quantum efficiency, speed of response, avalanche photodetector

Unit IV **(11 Hours)**

Characteristics of fiber optic communication system: Characterization of an optical fiber: measurement of its radius, numerical aperture, cut-off wavelength (Marcuse's formula) Analog and digital modulation (direct), noise in detection process: shot noise, thermal noise, SNR, Bit error rate (BER).

PRACTICAL COMPONENT: DIGITAL AND OPTICAL COMMUNICATION
(Hours: 30)

Students should perform at least six experiments from the following list:

1. Study Sampling theorem using software.
2. Study of Amplitude Shift Keying (ASK).
3. Study of Frequency Shift Keying (FSK).
4. Study Phase Shift Keying (PSK)- Binary Phase Shift Keying (BPSK)- and Quadrature Phase Shift Keying (QPSK)
5. Study of Quadrature amplitude Modulation (QAM).
6. To study the characteristics of LED.
7. To study the characteristics of semiconductor laser diode.
8. To study the characteristics of Silicon and Germanium photo-detectors.
9. To measure the parameters of a single mode optical fiber: radius, numerical aperture, cut-off wavelength.

REFERENCES

Essential readings

1. W. Tomasi, Electronic Communication Systems: Fundamentals through Advanced, Pearson Education (2024), 5th Edition
2. S. Haykin, Digital Communication, John Wiley India (Circa 2021), 3rd Edition
3. B. Sklar, Digital Communication, 2nd Edition, Pearson Education (2024)
4. J.G. Proakis, Fundamentals of Communication Systems, Pearson Education (2024), 2nd Edition

5. Ajoy Ghatak and K Thyagarajan, Introduction to Fiber Optics, Cambridge University Press, New Delhi (2024)
6. D.K. Mynbaev and Lowell L. Scheiner, Fiber-Optic Communication Technology, Pearson Education (2024).

Additional readings

1. L. W. Couch II, Digital and Analog Communication Systems, Pearson Education (2005)
2. H. P. Hsu, Analog and Digital Communications, Tata McGraw Hill (2006)
3. J. M. Senior, Optical fiber communication systems: principles and practice, Pearson Education in south Asia, (2009).
4. J. Gower, Optical communication systems, Pearson Education
5. G. Keiser, Optical communications, McGraw Hills education (2003)

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DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-1: CONSUMER ELECTRONICS IN DAILY LIFE

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Consumer Electronics in Daily Life DSE 8-1	4	3	0	1	

COURSE OBJECTIVES

This course aims to familiarize students with the basic principles, functioning, and practical applications of commonly used consumer electronic devices encountered in daily life. It provides an overview of sound and audio systems, television and video technologies, electronic gadgets, home appliances, and office automation tools, along with hands-on training for installation, operation, and basic troubleshooting.

LEARNING OUTCOMES

By the end of the course, students will be able to:

- Understand the basic characteristics of audio signals and the components involved in sound systems, including microphones, amplifiers, and loudspeakers.
- Explain the functioning and standards of television and video systems, including analog and digital formats.
- Describe the working principles of common household electronic gadgets and appliances such as air conditioners, washing machines, and microwave ovens.
- Demonstrate familiarity with office automation devices like laser printers, projectors, and video conferencing systems.
- Perform basic measurements, installations, interfacing, and market analysis of consumer electronic devices through practical exposure.

SYLLABUS OF DSE 8-1
THEORY COMPONENT
(Hours: 45)

Unit I **(15 Hours)**

Basic characteristics of sound signal: Audio level metering, Decibel Level in acoustic measurement, Level and Loudness, Pitch, Frequency response, Fidelity, Sensitivity and selectivity. Audio systems: PA system, Microphone, Amplifier, Loudspeakers. Radio receivers, AM/FM. Audio recording and reproduction, Cassettes, CD and MP3.

Unit II **(11 Hours)**

TV and Video systems: Television standards, BW/Colour, CRT/HDTV. Video system, VCR/VCD/DVD players, MP4 players, LCD, Plasma & LED TV. Projectors: DLP, Home Theatres, Remote Controls

Unit III **(11 Hours)**

Electronic Gadgets and Domestic Appliances (Basic working): Digital clock, Digital camera, Home security system, CCTV. Air conditioners, Refrigerators, Washing Machine/Dish Washer, Microwave oven, Vacuum cleaners

Unit IV **(8 Hours)**

Office Automation appliances (Basic Working): Laser Printer, Smart Interactive Board, LED Projector, Video conferencing system

PRACTICAL COMPONENT: CONSUMER ELECTRONICS IN DAILY LIFE
(Hours: 30)

Students should perform at least five experiments from the following list:

1. Testing and measurement of the various parameters of a microphone.
2. Test the given speaker and plot its frequency response.
3. Installation of Audio /Video systems – site preparation, electrical requirements, cables and connectors.
4. Market Survey of Products (at least one from each module)
5. To Interface and configure LED projector using various controls.
6. Study of PA systems for various situations – Public gathering, closed theatre /Auditorium, Conference room, Prepare Bill of Material (Costing)
7. Interface the laser printer to the desktop computer and identify various controls.

REFERENCES

Essential references

1. R. P. Bali Consumer Electronics Pearson Education (2008)
2. R. G. Gupta Audio and Video systems Tata McGraw Hill (2004)
3. Electronic Instrumentation by H.S Kalsi, McGraw Hill
4. Instrumentation measurements and analysis by Nakra & Choudhary
5. Measurement & Instrumentation- DVS Murthy
6. Electronic Sensor Circuits and Projects, III Volume, Forrest M Mims, Master Publishing Inc.

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DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-2: PHYSICS OF FIELD EFFECT DEVICES

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Physics of Field Effect Devices DSE 8-2	4	3	0	1	

COURSE OBJECTIVES

The objective of this course is to provide a comprehensive understanding of the principles, operation, and characteristics of Field Effect Transistors (FETs), including JFETs, MOSFETs, and advanced structures, while developing the analytical and practical skills needed to model, design, and analyze FET-based circuits in analog and digital systems.

LEARNING OUTCOMES

By the end of the course, students will be able to:

- Explain the operating principles, structural differences, and characteristics of various FET types, including JFETs and MOSFETs.
- Analyze I-V characteristics and apply small-signal models to understand FET behavior in different configurations.
- Design, simulate, and evaluate FET-based amplifier and switching circuits for analog and digital applications.
- Describe advanced FET technologies such as MESFETs and FinFETs, and critically assess challenges related to device scaling and performance.
- Apply knowledge of CMOS technology and nanoelectronic concepts to understand the role of FETs in integrated circuits and emerging electronic systems.

SYLLABUS OF DSE 8-2
THEORY COMPONENT
(Hours: 45)

Unit I **(11 Hours)**

Junction Field Effect Transistors (JFETs)
Overview of the structure and operational principles of JFETs, emphasizing voltage-controlled conduction via gate-source bias. Analysis of output and transfer characteristics, pinch-off voltage,

and drain current saturation. Study of various JFET biasing techniques and comparison with Bipolar Junction Transistors (BJTs). Applications of JFETs as amplifiers in Common Source (CS), Common Gate (CG), and Common Drain (CD) configurations.

Unit II **(12 Hours)**

Metal-Oxide-Semiconductor Field Effect Transistors (MOSFETs)
Detailed study of depletion-mode and enhancement-mode MOSFETs. Construction and operation of n-channel and p-channel MOSFETs. Analysis of MOS capacitors covering accumulation, depletion, and inversion modes, along with corresponding energy band diagrams. Concepts of threshold voltage, effects of work function differences, and interface charges. C-V characteristics, sub-threshold conduction, and MOSFET biasing techniques. Introduction to power MOSFETs, focusing on their high-voltage/current capabilities and switching performance.

Unit III **(11 Hours)**

Advanced FETs and Applications
Introduction to MESFETs including their structure, types, and short-channel behavior. Discussion of I-V modeling, field-dependent mobility, and two-region/two-dimensional models. High-frequency characteristics such as current cut-off frequency. Study of GaAs MESFETs. Overview of High Electron Mobility Transistors (HEMTs), including modulation doping and the formation of two-dimensional electron gas (2-DEG) at the AlGaAs/GaAs interface. Advantages and applications of HEMTs.

Unit IV **(11 Hours)**

FETs in Integrated Circuits and Nanoelectronics
Exploration of CMOS technology including structure and operation of nMOS, pMOS, and CMOS inverters. Introduction to VLSI design and the impact of channel length scaling. Effects such as body effect, thermal considerations, and reliability concerns. Fundamentals of hetero-epitaxial structures and emerging nanoelectronic components like quantum dots, nanowires, and two-dimensional layered materials.

<u>PRACTICAL COMPONENT: FIELD EFFECT TRANSISTORS</u>
(Hours: 30)

Students should perform at least six experiments from the following list:

1. Analyze the transfer and output characteristics of a Junction Field Effect Transistor (JFET).
2. Investigate the drain and transfer characteristics of an enhancement-mode MOSFET.
3. Examine the operating characteristics of a depletion-mode MOSFET.
4. Implement and evaluate the use of a MOSFET as an amplifier.
5. Study the frequency response of FET amplifiers in Common Source (CS), Common Gate (CG), and Common Drain (CD) configurations.
6. Perform load-line analysis for various FET circuit configurations.
7. Simulate FET-based circuits using SPICE or equivalent circuit simulation tools.
8. Characterize the behavior and switching properties of a CMOS inverter.

9. Determine the threshold voltage and transconductance of a MOSFET.
10. Investigate the switching characteristics of MOSFET devices under different operating conditions.
11. Simulate or measure the I-V characteristics of a High Electron Mobility Transistor (HEMT) and observe the formation of 2DEG.
12. Analyze the high-frequency response and current cut-off behavior of a MESFET using simulation.

REFERENCE

Essential Readings for the Theory Component

- B. G. Streetman, *Solid State Electronic Devices*, PHI.
- S. M. Sze, *Physics of Semiconductor Devices*, John Wiley & Sons.
- Neil Weste & David Harris, *CMOS VLSI Design*, Pearson.
- P. Valizadeh, *Field Effect Transistors: A Comprehensive Overview*, Wiley-Blackwell.
- R. F. Pierret, *Semiconductor Device Fundamentals*, Pearson Education.

Additional Reading for the Theory Component

- Kelly Fotheringham, *MOSFET and GaN FET Application Handbook*, Nexperia UK Ltd.

Essential Readings for the Lab Component

- Stephen A. Campbell, *The Science and Engineering of Microelectronic Fabrication*, Oxford University Press.
- Paul Horowitz and Winfield Hill, *The Art of Electronics*, 3rd Edition, Cambridge University Press.
- B. Somanathan Nair, *Electronic Devices and Applications*, PHI Learning.
- N. N. Bhargava, D. C. Kulshreshtha, S. C. Gupta, *Laboratory Manual for Electronic Devices and Circuits*, Tata McGraw-Hill

B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-3: NANOSCIENCE AND NANOTECHNOLOGY

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Nanoscience and Nanotechnology DSE 8-3	4	3	0	1	Quantum Mechanics

COURSE OBJECTIVES

The objective of this course is to introduce students to the fundamental principles of nanoscience and nanotechnology, with a focus on size-dependent properties of materials and their interdisciplinary applications. It aims to develop an understanding of nanomaterial synthesis, characterization techniques, and emerging applications in electronics, energy, environment, and healthcare.

LEARNING OUTCOMES:

Upon successful completion of this course, students will be able to:

- Explain the fundamental concepts of nanoscience and the distinct properties of nanomaterials compared to bulk materials.
- Classify nanomaterials based on their dimensions and understand quantum confinement effects on their behavior.
- Apply suitable top-down and bottom-up techniques for the synthesis of nanomaterials.
- Use standard characterization methods (e.g., XRD, SEM, TEM, UV-Vis) to analyze structural and optical properties of nanomaterials.
- Evaluate the potential of nanomaterials in real-world applications such as electronics, energy devices, sensors, and environmental solutions.

SYLLABUS OF DSE 8-3
THEORY COMPONENT
(Hours: 45)

Unit I **(12 Hours)**

Introduction to Nanoscience and Nanomaterials
Basic Concepts of Nanoscience and Nanotechnology: Introduction to nanoscience and its implications in Physics, Chemistry, Biology, and Engineering. Classification of nanostructured

materials: 0D (quantum dots), 1D (nanowires, nanotubes), 2D (thin films, graphene), and 3D (multi-layered materials, superlattices). Comparison of nanomaterials with bulk materials (metals, semiconductors, ceramics, polymers).
Properties at Nanoscale: Overview of mechanical, electronic, optical, magnetic, and thermal properties at nanoscale (qualitative). Effects of size reduction on these properties. Introduction to quantum confinement and its role in altering Bandgap widening, enhanced reactivity, and surface-to-volume ratio effects.

Unit II **(6 Hours)**

Nanoscale Systems and Their Properties
Band structure and density of states in 3D, 2D, 1D, and 0D systems (detailed for 3D and 2D, qualitative for 1D and 0D). Quantum confinement effects on electronic and optical properties.

Unit III **(15 Hours)**

Synthesis and Characterization of Nanomaterials
Synthesis Techniques: Top-down vs. bottom-up approaches. Top-down: Ball milling, lithography. Bottom-up: Physical Vapor Deposition (PVD) - thermal evaporation, sputtering; Chemical Vapor Deposition (CVD); Spin coating; Preparation of colloidal solutions (metals, metal oxides). Chemical and electrochemical synthesis of conducting polymers (intrinsic and extrinsic).
Characterization of Nanomaterials: Basic techniques for characterizing nanomaterials: Structural (e.g., SEM, TEM, AFM, XRD), optical (e.g., UV-Vis spectroscopy), and electronic properties (e.g., conductivity measurements).
Nanomaterials in Electronics: Introduction to carbon-based nanomaterials (CNTs, graphene) for electronic applications. Conductance quantization in 1D and 2D systems and their relevance to nanoelectronics.

Unit IV **(12 Hours)**

Applications of Nanomaterials
Nanomaterials in Energy and Environment: Nanotechnology for sustainable energy: Nanomaterials in solar cells (silicon-based, LEDs for displays), fuel cells, and electrochemical storage (primary, secondary, lithium, solid-state batteries). Environmental applications: Photocatalysts, nanomaterial-based membranes, and adsorbents for water/wastewater treatment (metal oxide surfaces, hybrid adsorbents).
Nano Devices and Sensors: Gas sensors: Chemiresistive (semiconducting metal oxides, CNT-based), electrochemical, and optical sensors.
Applications: Medical diagnostics (nanoprobes, targeted drug delivery), consumer products (sunscreens, lotions, paints).

PRACTICAL COMPONENT: NANOSCIENCE AND NANOTECHNOLOGY
(Hours: 30)

At least 05 experiments from the following:
1. Synthesis of metal/metal oxide nanoparticles by chemical route and study its optical absorption properties.

2. Synthesis of semiconductor (CdS/ZnO/TiO2/Fe2O3 etc) nanoparticles and study its XRD.
3. Analysis of XRD pattern of given nanomaterial and estimate lattice parameters and particle size.
4. Growth of thin films using thermal evaporation/spin coating or any available technique in lab.
5. Investigation of grain size/ particle size distribution from SEM/TEM images using imagej software (free ware: https://imagej.en.softonic.com/).
6. Prepare a ceramic disc of a given compound and study I-V characteristics / measure its dielectric constant with frequency or other property.
7. To study variation of resistivity or sheet resistance with temperature of the fabricated thin films using four probe method.

REFERENCES

Essential Readings for the theory component

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt. Ltd..
2. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company)
3. K. K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Introduction to Nanoelectronics, V. V. Mitin, V.A. Kochelap and M.A. Stroscio,2011, Cambridge University Press.
5. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).
6. Introductory Nanoscience by Masaru Kuno, (2012) Garland science Taylor and Francis Group
7. Electronic transport in mesoscopic systems by Supriyo Datta (1997) Cambridge University Press.
8. Fundamentals of molecular spectroscopy by C. N. Banwell and E. M. McCASH, 4th edition, McGrawHill.
9. Introduction to Nanomaterials and Devices, Omar Manasreh, Wiley, 1st Edition, 2011
10. Textbook of Nanoscience and Nanotechnology, B.S. Murty, P. Shankar, Baldev Raj, B.B. Rath, James Murday, 2013, Springer, e-ISBN 978-3-642-28030-6

Additional Readings for the theory component

1. Quantum Transport in semiconductor nanostructures by Carla Beenakker and HenK Van Houten (1991) (available at arXiv: cond-mat/0412664) Open Source
2. Sara Cronewett Ph.D. thesis (2001) for extra reading (Available as Arxiv).
3. Solid State Physics by J. R. Hall and H. E. Hall, 2nd edition (2014) Wiley

References for the laboratory work

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt. Ltd..
2. S. K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital

Publishing Company)
3. K. K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and
4. Technology (2009) (PHI Learning Private Limited).
5. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.)

B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-4 : SEMICONDUCTOR DEVICES - FABRICATION AND APPLICATIONS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Semiconductor Devices - Fabrication and Applications DSE 8-4	4	2	0	2	

COURSE OBJECTIVES

- This course provides a review of basics of semiconductors such as energy bands, doping, defects etc. and introduces students to various semiconductor and memory devices.
- Thin film growth techniques and processes including various vacuum pumps, sputtering, evaporation, oxidation and VLSI processing are described in detail.
- By the end of the syllabus, students will have an understanding of MEMS based transducers.

LEARNING OUTCOMES

At the end of this course, students will be able to achieve the following learning outcomes:

- Learn to distinguish between single crystal, polycrystalline and amorphous materials based on their structural morphology and learn about the growth of single crystals of silicon, using Czochralski technique, on which a present day electronics and IT revolution is based. Students will understand about the various techniques of thin film growth and processes.
- Appreciate the various VLSI fabrication technologies and learn to design the basic fabrication process of R, C, P- N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology.
- Gain basic knowledge on overview of MEMS (MicroElectro-Mechanical System) and MEMS based transducers.

SYLLABUS OF DSE 8-4

THEORY COMPONENT

(Hours: 30)

Unit I **(9 Hours)**

Introduction: Review of energy bands in materials. Metal, Semiconductor and Insulator. Doping in Semiconductors, Defects: Point, Line, Schottky and Frenkel. Single Crystal, Polycrystalline and Amorphous Materials. Czochralski technique for Silicon Single Crystal Growth. Silicon Wafer Slicing and Polishing.
Vacuum Pumps: Primary Pump (Mechanical) and Secondary Pumps (Diffusion, Turbomolecular, Cryopump, Sputter - Ion)– basic working principle, Throughput and Characteristics in reference to Pump Selection. Vacuum Gauges (Pirani and Penning).

Unit II **(10 Hours)**

Thin Film Growth Techniques and Processes: Sputtering, Evaporation (Thermal, electronBeam), Pulse Laser Deposition (PLD), Chemical Vapor Deposition (CVD). Epitaxial Growth. Thermal Oxidation Process (Dry and Wet) Passivation. Metallization. Diffusion.

Unit III **(7 Hours)**

VLSI Processing: Clean Room Classification, Line width, Photolithography: Resolution and Process, Positive and Negative Shadow Masks, Photoresist, Step Coverage, Developer. Electron Beam Lithography. Etching: Wet Etching. Dry etching (RIE and DRIE). Basic Fabrication Process of R, C, P-N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology. Wafer Bonding, Wafer Cutting, Wire bonding and Packaging issues (Qualitative idea).

Unit IV **(4 Hours)**

Micro Electro-Mechanical System (MEMS): Introduction to MEMS, Materials selection for MEMS Devices, Selection of Etchants, Surface and Bulk Micromachining, Sacrificial Subtractive Processes, Additive Processes, Cantilever, Membranes. General Idea MEMS based Pressure, Force, and Capacitance Transducers.

PRACTICAL COMPONENT: SEMICONDUCTOR DEVICES - FABRICATION AND APPLICATIONS

(Hours: 60)

At least 6 experiments from the following:

1. Fabrication of thin films via dip-coating technique, deposition of metal contacts through thermal evaporation and investigation of their current–voltage (I–V) characteristics.
2. Fabrication of thin films via spin-coating technique, deposition of metal contacts through thermal evaporation and investigation of their current–voltage (I–V) characteristics
3. Fabrication of p-n junction using either p or n type substrate along with

appropriate semiconducting layer and study its current-voltage (I-V) Characteristics.

4. Generation of vacuum in small tubes (varying volumes) using a mechanical rotary pump and measurement of pressure using vacuum gauges.
5. Selective etching of Different Metallic thin films using suitable etchants of different concentrations.
6. Wet chemical etching of Si for Micro-Electro-Mechanical Systems (MEMS) applications using different concentrations of etchant.
7. Calibrate semiconductor type temperature sensor (AD590, LM 35, LM 75).
8. To measure the resistivity of a germanium (Ge) semiconductor crystal with temperature (up to 150 ^{o}C) by four-probe method.
9. Capacitance measurements of ceramics using LCR meter.
10. Capacitance measurements of dielectric thin film capacitor using LCR meter

REFERENCES

Essential Readings for the theory component

1. Physics of Semiconductor Devices, S. M. Sze. Wiley-Interscience.
2. Fundamentals of Semiconductor Fabrication, S.M. Sze and G. S. May, John-Wiley and Sons, Inc.
3. Introduction to Semiconductor materials and Devices, M. S. Tyagi, John Wiley & Sons VLSI Fabrication Principles (Si and GaAs), S. K. Gandhi, John Wiley & Sons, Inc.

Additional Readings for the theory component

Handbook of Thin Film Technology, Leon I. Maissel and Reinhard Glang.

Essential Readings for the practical theory component

1. The science and Engineering of Microelectronics Fabrication, Stephen A. Champbell, 2010, Oxford University Press.
2. Introduction to Semiconductor Devices, Kelvin F.

B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8-5: SENSORS AND DETECTORS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Sensors and Detectors DSE 8-5	4	3	0	1	

COURSE OBJECTIVES

To make students familiar with the constructions and working principle of different types of sensors and transducers. To make students aware about the measuring instruments and the methods of measurement and the use of different transducers.

LEARNING OUTCOMES

At the end of the course, a student will be able to:

- Use concepts in common methods for converting a physical parameter into an electrical quantity.
- Classify and explain with examples of transducers, including those for measurement of temperature, strain, motion, position and light.
- Choose proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc.
- Predict correctly the expected performance of various sensors.
- Locate different type of sensors used in real life applications and paraphrase their importance.
- Set up testing strategies to evaluate performance characteristics of different types of sensors and transducers and develop professional skills in acquiring and applying the knowledge outside the classroom through design of a real-life instrumentation system.

<u>SYLLABUS OF DSE 8-5</u>
<u>THEORY COMPONENT</u>
(Hours: 45)

Unit I **(13 Hours)**

Transducers, Classification of transducers on different basis, Types of transducers (Basic idea of Mechanical, resistive, capacitive, inductive, piezoelectric, optical and digital).
Sensor, Components of sensor, Direct and complex sensor (Basic idea)
Distinction between Sensor and Transducer, Characteristics of Transducers/Sensor: Static characteristics and static calibration (Calibration accuracy and component error), Dynamic characteristics.
Inductive sensor: Variable Inductance Sensors, Plunger type displacement sensor, Variable Gap Sensor, LVDT: Construction, working, output characteristics. Idea of RVDT (Qualitative).
Capacitive sensors: Variable distance-parallel plate type, variable area- parallel plate (serrated plate/teeth type), variable dielectric constant type; Sensitivity of capacitive sensors, Stretched diaphragm type

Unit II **(9 Hours)**

Magnetic Sensors: Magnetoresistive Sensors and Hall effect sensor (performance and characteristics).
Temperature sensor: RTD (construction, working and temperature coefficient), thermistor, categories of thermistor (PTC and NTC: material, shape, ranges, RT curve and accuracy specification), Thermo emf sensor (thermoelectricity generation, thermos-emf measurement, Thermocouples (construction, characteristics), and Pyroelectric sensors (pyroelectric effect and output voltage-temperature relationship).

Unit III **(13 Hours)**

Pressure sensors: Direct versus indirect pressure measurement, Different types of gauges and their working range, Mechanical gauges (McLeod Gauge), Thermal Conductivity Gauges (Thermocouple and Pirani gauges) and Ionization gauges (hot & cold cathode), advantages and limitations of various types of gauges, Gauge calibration (Static: Manometric method and dead-beat tester, dynamic calibration).
Radiation Sensors: Basic Characteristics (Concept of Work Function, Spectral Sensitivity, Spectral threshold, Quantum yield, time lag, linearity, Status and dynamic response), Types of Photodetectors: Photoemissive Cell, Photo Multiplier, Photo conductive Cell (LDR), Photovoltaic cells, photodiodes. Detection of Nuclear Radiation: Qualitative treatment of Geiger Muller counters and Scintillation detectors.

Unit IV **(10 Hours)**

Applications of Sensors and detectors: Basic principles of Remote sensing, Introduction to LiDAR (principles, applications and benefits), Types of LiDAR (air-borne and ground based)
Applications of motion sensors in accelerometers and gyroscopes (qualitative analysis of

working principle).
Biomedical Sensor: Electrochemical sensor (electrochemical cell, cell potential, three electrodes system, working principle).

PRACTICAL COMPONENT: SENSORS AND DETECTORS
(Hours: 30)

At least 5 experiments to be done from the list below:

1. Characteristics of LDR as a function of distance from light source.
2. Light characteristics of Photodiode.
3. Measurement of Strain using Strain Gauge.
4. To study the characteristics of a Linear Variable Differential Transformer (LVDT).
5. To study the characteristics of a Resistance Temperature Device (RTD).
6. To study the frequency response of a loudspeaker.
7. Determine characteristics of an Infrared (IR) emitter-receiver module.
8. Create vacuum in a small chamber using a mechanical (rotary) pump and/or secondary pump and measure the chamber pressure using a pressure gauge – Pirani and/or CC gauge.
9. Measurement of thermos-emf in thermopile and to calculate the Seebeck coefficient.
10. Study the pyroelectric effect and generation of induced voltage with temperature change.

REFERENCES

Essential Readings for the Theory Component

1. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
2. Introduction to Measurements and Instrumentation, A.K. Ghosh, PHI Learning Pvt. Ltd.
3. 3.Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
4. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata
5. McGraw Hill
6. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer
7. Electronic Instrumentation by H. S. Kalsi (Mc Graw Hill Publisher)
8. Sensors and Transducers, D Patranabis, PHI Learning Pvt. Ltd.
9. An Introduction to Sensors and Instrumentations, Sobnath Singh, Narosa
10. Handbook of Modern Sensors, Jacob Fraden, Springer
11. Handbook of Thion film Technology, Maissel and Glang, Tata McGraw Hill
12. Instrumentation, Measurement and Analysis, Nakra and Chaudhry, McGraw Hill

Additional Readings for the Theory Component

1. Radiation detection and measurement, G.F. Knoll, Wiley

2. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M.Sayer and A. Mansingh, PHI

References for the Practical Component

1. Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, Springer
2. Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino, M. A. Miller, McGraw

B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

SKILL BASED COURSE – SBC 8-1: INTERFACING WITH ARDUINO

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Interfacing with Arduino SBC 8-1	2	0	0	2	SBC 7-1: Arduino Programming

COURSE OBJECTIVES

- Explain the architecture and features of the Arduino Platform.
- Set up and use the Arduino IDE to write, debug, and upload code to an Arduino board.
- Write basic programs involving digital and analog I/O, loops, functions, and conditional statements.
- Implement simple tasks such as blinking LEDs, reading buttons, generating PWM signals, and reading analog voltages.
- Understand serial communication and use the Serial Monitor for debugging.
- Design small-scale automation and control programs using Arduino logic.

LEARNING OUTCOMES

- Identify and describe the working principles of common sensors (e.g., temperature, light, distance) and actuators (e.g., motors, buzzers).
- Interface sensors (LDR, DHT11, ultrasonic, IR, etc.) with Arduino and acquire data.
- Control actuators (relays, DC motors, stepper motors, servos, buzzers) using digital output and PWM.
- Design simple projects such as automatic lighting systems, object detection alarms, or temperature monitors.
- Implement basic feedback and control systems (e.g., temperature-based fan control).
- Troubleshoot common hardware and communication issues in Arduino circuits.

SYLLABUS OF SBC 8-1
(Hours: 60)

Apart from common experiments for all students on the listed topics, project-based learning (group activities) to be encouraged.

Unit I **(24 Hours)**

Interfacing with Sensors and Actuators

- Working with Sensors: Introduction to sensors (temperature, humidity, light, magnetic field etc.). Reading analog values.
- Analog and Digital Inputs/Outputs: Analog vs. Digital signals. Working with potentiometers, photoresistors, and thermistors.
- Interfacing with Motors: Controlling DC motors. Introduction to servos and stepper motors.
- Using Displays and Keypads: Interfacing with 7-segment displays and LCDs. Using keypads for input.
- Sound and Audio Output: Working with buzzers and speakers. Generating sound with Arduino.

Unit II **(36 Hours)**

Communication Protocols and Advanced Topics.

- Serial Communication: Understanding UART and Serial Communication. Communication between Arduino and computer.
- I2C and SPI Communication: Introduction to I2C and SPI protocols. Interfacing with external modules (e.g., sensors, displays).
- Wireless Communication: Introduction to wireless modules (Bluetooth, Wi-Fi). Simple projects using wireless communication.
- Data Logging: Reading and storing data from sensors. SD card modules and data logging projects.
- Introduction to IoT with Arduino: Basics of the Internet of Things (IoT). Simple IoT project: Sending data to a web server.
- Planning and designing your project.

SUGGESTED READINGS

"Getting Started With Arduino" By Massimo Banzi and Michael Shiloh. Shroff/Maker Media; fourth edition (2022). ISBN-13 : 978-9391043858

B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

SKILL BASED COURSE – SBC 8-2:
WEATHER FORECASTING

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Weather forecasting SBC 8-2	2	1	0	1	

COURSE OBJECTIVES

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques.

LEARNING OUTCOMES

The student will gain the following:

- Acquire basic knowledge of the elements of the atmosphere, its composition at various heights, variation of pressure and temperature with height.
- Learn basic techniques to measure temperature and its relation with cyclones and anti-cyclones.
- Knowledge of simple techniques to measure wind speed and its directions, humidity and rainfall.
- Understanding of absorption, emission and scattering of radiations in atmosphere; Radiation laws.
- Knowledge of global wind systems, jet streams, local thunderstorms, tropical cyclones, tornadoes and hurricanes.
- Knowledge of climate and its classification. Understanding various causes of climate change like global warming, air pollution, aerosols, ozone depletion, acid rain.
- Develop skills needed for weather forecasting, mathematical simulations, weather forecasting methods, types of weather forecasting, role of satellite observations in weather forecasting, weather maps etc. Uncertainties in predicting weather based on statistical analysis.
- Develop ability to do weather forecasts using input data.
- In the laboratory course, students should be able to learn: Principle of the working of a weather Station, Study of Synoptic charts and weather reports, Processing and analysis of weather data, Reading of Pressure charts, Surface charts, Wind charts and their analysis.

SYLLABUS OF SBC 8-2
THEORY COMPONENT
(Hours: 15)

Unit -1 **(8 Periods)**

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement
Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.

Unit-2 **(7 Periods)**

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.
Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution and its measurement, particulate matters PM 2.5, PM 10. Health hazards due to high concentration of PM2.5; aerosols, ozone depletion.
Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

PRACTICAL COMPONENT: WEATHER FORECASTING
(Hours: 30)

Demonstrations and Experiments:
1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
   (a) To calculate the sunniest time of the year.
   (b) To study the variation of rainfall amount and intensity in different seasons.
   (c) To examine the maximum and minimum temperature throughout the year.
   (d) To study the relative humidity of the day and seasons and the entire year.
   (e) Development and movement of low and high Pressure system over Indian/global region.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and non-aviation).
5. Simulation of weather system

6. Field visits to India Meteorological department and National center for medium range weather forecasting

REFERENCES

Essential Readings

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
4. Text Book of Agro meteorology, S.R. Ghadekar, 2005,Agromet Publishers, Nagpur.
5. Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

Additional Reading:

1. PM2.5 diminution and haze events over Delhi during the COVID-19 lockdown period: an interplay between the baseline pollution and meteorology, Nature- Scientific Reports, 10(13442). https://doi.org/10.1038/s41598- 020-70179-8., S. K. Dhaka, Chetna, V. Kumar, V. Panwar, A. P. Dimri, N. Singh, P. K. Patra, Y. Matsumi, M. Takigawa, and T. Nakayama (2020)
2. Chapter 1 - Composition and thermal structure of the earth's atmosphere, Atmospheric Remote Sensing, Principles and Applications, Earth Observation, 2023, Pages 1-18, https://doi.org/10.1016/B978-0-323-99262-6.00023-7. SK Dhaka and Vinay Kumar.
3. Climatic trends in temperature, relative humidity, and wind speed over Indian landmass and isle in Andaman Nicobar and Lakshadweep during 1981-2021, MAPAN-Journal of Metrology Society of India, (2024), DOI: 10.1007/s12647-024-00743-4, Shristy Malik, A.S. Rao, S K. Dhaka.
4. Decoding temporal patterns and trends of PM10 pollution over Delhi: A multi-year analysis (2015–2022). Environmental Monitoring and Assessment, 196(6), 500. https://doi.org/10.1007/s10661-024-12638-7, Chetna, Dhaka, S. K., Walker, S.-E., Rawat, V., & Singh, N. (2024).

B.Sc. (NURSING) (POST BASIC)

DEPARTMENT OF NURSING

UNIVERSITY OF DELHI

Introduction:-

Nursing contributes to the health services in a vital and significant way in the health care delivery system. It recognizes national health policies and programs. It aims at identifying health needs of the people, planning and providing quality care in collaboration with other health professional and community groups.
National Health Policy 2002 lays emphasis on improving the skill level of nurses and on increasing the ratio of degree holding nurses vis-a –vis diploma holding nurses.In this direction the training of diploma holder to undergo B.Sc (Nursing)(Post Basic) course will help to achieve the objectives set by the National Health Policy. The overall aim of the course is to improve the quality of Nursing service to the patients in the hospital and community at large.

Overview of the B.Sc. (Nursing) (Post Basic) Course:-

Duration of the course:- Two Years (4 Semesters)

PHILOSOPHY:-

Nursing contributes to the health services in a vital & significant way in a health care delivery system. Its recognizes national health goals & is committed to participate in the implementation of national Health Policies and Programs. It aims at identifying health needs of people, planning & providing quality care in collaboration with other health professionals & community groups.

Undergraduate nursing program at the post basic level is a broad based education within an academic framework,which builds upon the skills and competencies acquired at the diploma level of nursing education,it is specifically directed to upgrading of critical thinking skills,competencies & standards required for practice of professional nursing and midwifery as envisaged in National Health Policy.

Under graduate nursing education program at the post basic level prepares its graduates to become exemplary citizen by adhering to code of ethics & professional conduct at all times in fulfilling personal,social and professional obligations so as to respond to national aspirations.

AIMS:-

The aim of the undergraduate nursing program at the post basic level is to upgrade the diploma (GNM) nurses to :-

- Assume responsibilities as professional, competent nurses and midwives at basic level providing promotive, preventive, curative and rehabilitative services.
- Make independent decisions in nursing situations, protect the rights of and facilitate individuals and groups in pursuit of health, function in the hospital, community nursing services and conduct research studies in the areas of nursing practice. They are also expected assume the role of teacher, supervisor, manager in clinical/public health setting.

Objectives:-

On completion of B.Sc. Nursing (Post –Basic) degree program the graduates will be able to:

1. Assess health status, identify nursing needs, plan, implement and evaluate nursing care for patients/clients that contribute to health of individuals, families and communities.
2. Demonstrate competency in techniques of nursing based on concept and principles from selected areas of nursing, physical, biological and behavioral sciences.
3. Participate as members of health team in the promotive, preventive, curative and restorative health are delivery system of the country.
4. Demonstrate skills in communication and interpersonal relationship.
5. Demonstrate leadership qualities and decision making abilities in various situations.
6. Demonstrate skills in teaching to individuals and groups in community health settings.
7. Demonstrate managerial skills in community health settings.
8. Practice ethical values in their personal and professional life.
9. Participate in research activities and utilize research findings in improving nursing practice.
10. Recognize the need for continued learning for their personal and professional development.

A minimum of 80% attendance in theory & practical/clinical in each subject is essential for appearing in the examination.

Eligibility Criteria For Admission:-

A candidate seeking admission to Post Basic B.Sc. Course should have passed 10+2 and General Nursing and Midwifery from INC recognized institution with minimum 50% marks in the aggregate.

1. Those who have done 10+1 in or before 1986, will be eligible for admission.

- Candidates shall be medically fit.
- Students shall be admitted once in a year.

Basic of Selection:-

The selection of the candidates will be done on the merit of selection test. All candidates Irrespective of reserved or non-reserved category, have to appear for the selection test.

Proposed plan for B.Sc. (Nursing) (Post Basic) program

Semester -I

Paper No.	Course	Theory Hours	Practical Hours
I	Nursing Foundation&Professionalism (Part A)& Nutrition & Dietetics(Part B)	60 + 30 (3 + 1 Credits)	15
II	Microbiology	60 (3 Credits)	30
III	Medical Surgical Nursing	120(6 Credits)	270 (3 Credits)
IV	Psychology	60 (3 Credits)	15
	EVS	30 (1 Credits)	
	Total Hours	360 (17 credits)	330 (3 Credits) = 690 (20 Credits)

Semester –II

Paper No.	Course	Theory Hours	Practical Hours
V	Maternal Nursing	60 (3 Credits)	240 (3 Credits)
VI	Child Health Nursing	60 (3 Credits)	240 (3 Credits)
VII	English	60 (3 Credits)	
VIII	Biochemistry & Biophysics	60 (3 Credits)	
	Total Hours	240 (12 Credits)	480 (6 Credits) = 720 (18 Credits)

Semester –III

Paper No.	Course	Theory Hours	Practical Hours
IX	Mental Health Nursing	60 (3 Credits)	240 (3 Credits)
X	Sociology	60 (3 Credits)	
XI	Introduction to Nursing Research & Statistics	60 (3 Credits)	120 (1 Credit)
XII	Health/ Nursing Informatics & Forensic Nursing	20 + 20 (2 Credits)	
	Integrated Clinical experience (All Specialties)		120 (1 Credit)
	Total Hours	220 (11 Credits)	480 (6 Credits) = 700(17 Credits)

Semester – IV

Paper No.	Course	Theory Hours	Practical Hours
XIII	Community Health Nursing	60 (3 Credits)	240 (3 Credits)
XIV	Introduction to Nursing Education	60 (3 Credits)	120 (1 Credit)
XV	Introduction to Nursing Administration	60 (3 Credits)	180 (2 Credits)
	Total Hours	180 (9 Credits)	540(6 Credits) = 720(15 Credits)

UNIVERSITY OF DELHI
B.Sc. (NURSING)(POST BASIC)
SCHEME OF EXAMINATION

Paper	Course	Assessment					
		Theory			Practical		
		Int.	Ext.	Total	Int.	Ext.	Total
I	Nursing Foundation & Nutrition & Dietetics	25	75	100			
II	Microbiology	25	75	100			
III	Medical- Surgical Nursing	25	75	100	50	50	100
IV	Psychology	25	75	100			
	EVS						

Semester - II

Paper	Course	Assessment					
		Theory			Practical		
		Int.	Ext.	Total	Int.	Ext.	Total
V	Maternal Nursing	25	75	100	50	50	100
VI	Child Health Nursing	25	75	100	50	50	100
VII	English	25	75	100			
VIII	Biochemistry & Biophysics	25	75	100			

Semester - III

Paper	Course	Assessment					
		Theory			Practical		
		Int.	Ext.	Total	Int.	Ext.	Total
IX	Mental Health Nursing	25	75	100	50	50	100
X	Sociology	25	75	100			
XI	Introduction to Nursing Research & Statistics *	25+25		* 50			
XII	Introduction to Nursing Administration	25	75	100			
XIII	Health/ Nursing Informatics & Forensic	25+25		*50			

Semester - IV

Paper	Course	Assessment					
		Theory			Practical		
		Int.	Ext.	Total	Int.	Ext.	Total
XIV	Community Health Nursing	25	75	100	50	50	100

XV	Introduction to Nursing Education	25	75	100			
	Research Practical					** 50	100

*** College Exam**
**** Research Project**

Post Basic B. Sc. Nursing

Paper I: - Nursing Foundation, Professionalism and Nutrition & Dietetics

Placement: First Year(I Semester) Part A- Theory-60 Hrs.

Part B- Theory -30 Hrs.
Practical-15Hrs

Part A- Nursing Foundation & Professionalism

COURSE CONTENTS

UNIT I

* Development of nursing as a profession - its philosophy , objectives and responsibilities of a graduate nurse
* Trends influencing nursing practice
* Expanded role of the nurse
* Development of nursing education in India and trends in nursing education.
* Professional organization , career planning
* Code of ethics & professional conduct for nurses.
* Critical thinking & Nursing judgment

UNIT II

* Ethical, legal and other issues in nursing
* Concepts of health and illness, effects on the person
* Stress and adaptation.
* Health care concept and nursing care concept.
* Developmental concept, needs, roles and problems of the developmental stages of individual- new born, infant , toddler, pre-adolescent, adolescent, adulthood ,middle- age, old age

UNIT III

* Concepts & theoretical models **is** nursing practice
* Meta paradigm of nursing- characterized by four central concepts i.e nurse , person(client/ patient), health and environment.

UNIT IV

* Nursing process.
* Assessment: Tools for assessment, methods, recording.
* Planning: Techniques for planning care, types of care plans.
* Implementation: Different approaches to care, organizations and implementation of care, recording.
* Evaluation: Tools for evaluation , process of evaluation.

UNIT V

* Quality assurance: nursing standards, nursing audit, total quality management
* Role of council and professional bodies in maintenance of standards.

UNIT VI

* Primary health care concept:- community oriented nursing, holistic nursing, primary nursing
* Family oriented nursing concept :- problem oriented nursing, progressive patient care, team nursing

UNIT VII

PROFESSIONALISM

Professionalism

- Definition and characteristics of professionalism.
- Concepts, attributes and indicators of professionalism.
- Challenges of professionalism Challenges of professionalism
    - Personal identity vs professional identity
    - Preservation of self-integrity threat to integrity, Deceiving patient: withholding information and falsifying records
    - Communication & Relationship with team members: Respectful and open communication and relationship pertaining to relevant interests for ethical decision making.
    - Relationship of with patients and society.

Professional values

- Values: Definition and characteristics of values
- Value clarification
- Personal and professional values
- Professional socialization: Integration of professional values with personal values.

Professional values in nursing

- Importance of professional values in nursing and health care
- Caring definition and process
- Compassion: Sympathy Vs empathy, Altrusim
- Conscientiousness
- Dedication devotion to work
- Respect for the person- Human dignity
- Privacy and confidentiality: Incidental disclosure
- Honesty and integrity: Truth telling
- Trust and credibility: Fidelity, Loyalty
- Advocacy: Advocacy for patients, work environment, nursing education and practice and for advancing the profession.

Ethics & Bioethics

Definitions: Ethics, Bioethics and Ethical Principles

- Beneficence
- Non-maleficence: Patient safety, protecting patient from harm, Reporting errors
- Justice: Treating each person as equal
- Care without discrimination, equitable access to care and safety of the public
- Autonomy: Respects patient's autonomy, Self -determination Freedom of choice

Ethical issues and ethical dilemma: Common ethical problems

- Conflict of interest
- Paternalism'
- Deception
- Privacy and confidentiality
- Valid consent and refusal

- Allocation of scarce nursing resources
- Conflicts concerning new technologies
- Whistle-blowing

- *Beginning of life issues*
  - Abortion
  - Substance abuse
  - Fetal therapy
  - Selective deduction
  - Intrauterine treatment of fetal conditions
  - Mandated contraception
  - Fetal injury
  - Infertility treatment

- *End of life issues*
  - End of life
  - Euthanasia
  - Do Not Resuscitate (DNR)

- *Issues related to psychiatric care*
  - Non compliance
  - Restrain and seclusion
  - Refuse to take food

Process of ethical decision making

- Assess the situation (collect information)
- Identify the ethical problem
- Identify the alternative decisions
- Choose the solution to the ethical decision
- Implement the decision
- Evaluate the decision

Ethics committee: Roles and responsibilities

- Clinical decision making
- Research

Rights of Patient

Patients' Bill of Rights-17 patients' rights (MoH&FW, GoI)

1. Right to emergency medical care
2. Right to safety and quality care according to standards
3. Right to preserve dignity
4. Right to non-discrimination
5. Right to privacy and confidentiality
6. Right to information
7. Right to records and reports
8. Right to informed consent
9. Right to second opinion
10. Right to patient education
11. Right to choose alternative treatment options if available
12. Right to choose source for obtaining medicines or tests
13. Right to proper referral and transfer, which is free from perverse commercial influences
14. Right to take discharge of patient or receive body of deceased from hospital
15. Right to information on the rates to be charged by the hospital for each type of service provided and facilities available on a prominent display board and a brochure

16. Right to protection for patients involved in clinical trials, biomedical and health research
17. Right to be heard and seek redressal

NURSING FOUNDATION
SUGGESTED READING

1. Taylor, C. et al. Fundamental of Nursing: The Art and Science of Nursing Care
   Edition, U.S. Lippincott Williams an Wilkins publishers,
2. Potter. P.A and Perry, A.G. Fundamental of Nursing Concepts Process and Practice
   Edition, USA; Elsevier Publication.

3. Kozier, B.et al Kozier & Erb's Fundamental of Nursing.
   8th Edition, New Delhi, India: Pearson Education Publisher 2009.

4. The Trained Nurses Association of India: Fundamental of Nursing- A Procedure manual.
   1st Edition, India: Aravali Publisher 2005.

Part B- Nutrition & Dietetics

Placement: First Year (II Semester) — Theory – 30 hrs, Practical- 15 hrs

COURSE CONTENTS

UNIT I

* Introduction to nutrition and dietetics.
* Balanced diet, factors on which it depends
* Factors to be considered in planning.
* Guides available for planning.
* Food Hygiene, preparation and preservation.
* Review of nutrients- micro & macro.

UNIT II

* Introduction to diet therapy.
* Routine hospital diets.
* Therapeutic diet under each unit i.e. cardiovascular diseases, Gastrointestinal diseases. Renal Disorders. Endocrine and metabolic disorders. Allergy, Infections and fevers, Pre and post-operative Stage .Deficiency diseases and malnutrition, overweight and underweight.

UNIT III

* Infant and child Nutrition
* Feeding of normal infants: factors to be considered in planning, nutritional requirements.
* Feeding of premature infants: factors to be considered in planning, nutritional requirements.
* Supplementary feeding of infants: Advantage and method of introduction.
* Weaning, effects on Mother and Child
* Psychology of infant and child feeding.
* Feeding the sick child. Diet in diseases of infancy and childhood.
* Deficiency states- malnutrition and under nutrition.
* Feeding pre- school child: nutritional needs, factors to be considered in planning diets. Problems in feeding.
* School lunch programme: Advantages, Need in India

UNIT IV

* Community Nutrition: Need for community nutrition programme.
* Nutritional needs for special groups: infant, child, adolescent, pregnant woman, lactating mother and old people.
* Substitutes for non- vegetarian foods.
* Selection of cheap and nutritious foods, Nutrition education-needs and methods.
* Methods of assessing nutritional status of individual/ group/ community
* Current nutritional problems and national programmes.

PRACTICUM

I. Methods of cooking and cookery rules

1. Simple preparation of beverage , soups, cereals and pulses, eggs, vegetables , meat.
2. Menu plans.

II **Preparation of supplementary food for infants**

1. Food for toddlers.
2. Low cost nutritious dishes for vulnerable groups.
3. Dietary case study of patient on special diet and planning of low cost dietary instructions for home adaptations.
4. Planning of therapeutic diets.

Suggested Reading:

1. Mahan, L.K. And Escott- stumpy, S. Krause's Food , Nutrition and Diet Therapy. W.B. Saunders, Co. 12th Edition, 2008.
2. Kumud Khanna et.al Text Book of Nutrition and Dietetics, Elite Publishing House Pvt. Led. 2006.
3. Srilakshmi B. Nutrition science, New age International Publishers ,2008.
4. Sushma Sharma, Arvind Wadhwa, Nutrition in the Community A Textbook. Elite Publishing Pvt. Ltd. , 2006
5. Gopalan. C. Ramasastri, B.V. Et al Nutritive value of Indian Foods, National Institution of Nutrition ICMR publication, 2004.

Paper II: - Microbiology

Placement: First Year (I Semester) Theory - 60 hrs.
Practical - 30 hrs.

COURSE CONTENTS

UNIT I

* Structure and classification of microbes
* Morphological types.
* Size and form of bacteria
* Motility
* Classification of micro-organisms

Practical:

Use and care of microscope

Common examination: Smear, Blood, Moulders, Yeasts.

UNIT II

* Identification of micro- organisms
* Discussion of laboratory methods.
* Diagnosis of bacterial diseases.

Practical:

Staining techniques- gram staining, acid fast staining.

Hanging drop preparation.

UNIT III

* Growth and Nutrition of microbes
* Temperature
* Moisture
* Blood

Practical

Preparation of media and culture techniques.
Collection, handling and transportation of various specimens

UNIT IV

* Destruction of micro-organisms
* Sterilization and disinfection
* Chemotherapy and antibiotics.
* Effects of heat and cold
* Hospital infection control procedures& role of nurses.

Practical: Sterilization methods – physical, chemical and mechanical

UNIT V

* Disease producing micro- organisms, gram positive bacilli, tuberculosis and Leprosy, Anaerobes, Cocci, Spirochetes, Rickettsiae

Practical; Identification and study of the following bacteria: Streptococci, pneumococci and staphylococci, corynebacteria, spispirochete and gonococci. Enteric bacteria. Posting in infection control department.

UNIT VI

* Immunity:- Immunity and hypersensitivity - skin test, Antigen and antibody reaction, Immunization in disease.

Practical: demonstration of serological methods.

UNIT VIII

* Parasites and vectors:- characteristics and classification of parasites, protozoal infection including amoebiasis
* Helminthes infections Diagnosis of parasitic infection, Vectors and diseases transmitted by them.

Practical:- Identification of Parasites and Vectors.

UNIT IX

* Viruses:- classification and general character of viruses, diseases caused by viruses in man and animal and their control.

UNIT X

- Micro- organisms transmitted through food. Food poisoning , food borne infections.

Suggested Reading:-

1. Gupte, satish, short Text Book of Medical Microbiology, 8th Edition, India, Jaypee Publishers, 2002
2. Mehrotra, R M L Microbiology for Medical Students, 3rd Edition, India: College book Publishers, 1979.
3. Power, C.B. And Daginawala, H.F. General Microbiology . 1st Edition, India Himalaya, Publishers,1982.
4. Dey, N.C. And Dey, T;K. Medical Parasitology 8th Edition, India: Allied Agency Publishers, 1980.
5. Pelczar, J.R. al et Microbiology 4th Edition, New York: Tata Mc Graw Hill, Publication1978.

Paper III: - Medical Surgical Nursing

Placement : First Year (I semester) — Theory -90 hrs. Practical- 270hrs

COURSE CONTENTS

UNIT I

* Introduction to medical surgical nursing.
* Review of concepts of comprehensive nursing care in medical surgical conditions.
* Nurse, patient and his/ her family
* Functions of nurse in the out patient department.
* Intensive care unit.

UNIT II

* Nursing management of patient with specific problems
* Fluid and electrolyte imbalance
* Dyspnea and cough, respiratory obstruction.
* Fever
* Shock
* Unconsciousness
* Pain
* Acute illness
* Chronic illness
* Terminal illness
* Age related illness
* Patient under going surgery
* Incontinence

UNIT III

* Nursing management of patient with neurological and neurosurgical conditions
* Review of anatomy and physiology of the nervous system.
* Pathophysiology. Diagnostic procedures and management of:
* Cerbro- vascular accident
* Cranial, spinal and peripheral neuropathies
* Epilepsy
* Infectious and inflammatory diseases and trauma of the nervous system.
* Common disorders of the system
* Recent advances in diagnostic and treatment modalities.
* Drugs used in these disorders
* Tumors of brain and spinal cord, congenital malformations, degenerative diseases.

UNIT IV

Nursing management of patient with cardiovascular problems
Review of relevant anatomy and physiology of cardio vascular system.
Pathophysiology ,diagnostic procedures and management of:
Ischemic heart diseases.
Cardiac arrhythmia
Congestive heart failure
Rheumatic and other valvular heart diseases.
Endocarditis, cardiomyopathies congenital heart diseases, hypertension, heart block.
Cardiac emergencies: cardiac arrest, acute pulmonary oedema, cardiac, tamponade, cardiogenic shock, aneurysms and

peripherovascualr disorders, recent advancement in cardiology.

UNIT V

Nursing management of patient with respiratory problems:
Review of anatomy and physiology of respiratory system, pathophysiology , diagnostic procedures and management of upper respiratory tract infections.
Bronchitis
Asthma
Emphysema, empyema, Atelectasis, COPD
Bronchiectasis
Pneumonia
Pulmonary tuberculosis
Lung abscess
Pleural effusion
Tumor and cysts.
Chest injuries
Respiratory arrest and insufficiency
Pulmonary embolism
Drugs used in the management of these patients
Special respiratory therapies.

UNIT VI

Nursing management of patient with genito- urinary problems
Review of anatomy and physiology of the genito- urinary system.
Nephritis
Renal calculus
Acute renal failure
Chronic renal failure
End stage renal disease.
Special procedures , dialysis, renal transplant.
Drugs used in management of these patients
Congenital disorders, urinary infections.
Benign prostate hypertrophy

UNIT VII

Nursing Management of patients with problems of the digestive systems.
Review of anatomy and physiology of gastrointestinal system and accessory organs
Pathophysiology, diagnostic procedures and management of :-
G.I. bleeding
Peptic ulcer
Infections, Acute abdomen
Colitis, diarrhea, dysentery and mal-absorption syndrome
Cholecystitis.
Hepatitis, hepatic coma and cirrhosis of liver.
Portal hypertension
Pancreatits
Tumors, hernias, Fistulas, fissures, hemorrhoids.
Drugs used in the management of these patients

UNIT VIII

Nursing management pf patients with endocrine problems
Review of anatomy and physiology and patho physiology of patients with
Thyroid disorders
Diabetes mellitus
Diabetes insipidus

Adrenal tumor
Pituitary disorders
Diagnostic procedures
Nursing management of patient with above problems
Drugs used in endocrine problems.

UNIT IX
Nursing management of patient with musculoskeletal problems
Review of anatomy and physiology and pathophysiology
Arthritis, Osteomyelitis bursitis,
Fractures , dislocation and trauma
Prolapsed disc Osteomalcia and osteoporosis
Tumor
Amputation
Diagnostic procedures
Nursing management of patients with above problems
Prosthesis and rehabilitation.
Transplant & replacement surgeries.

UNIT X
Nursing management of patients with disorders of female reproductive tract.
Disorders of menstruation
Infections of the genital tract.
Benign and malignant tumors of the genital tract.
Rectovaginal fistula, vesicovaginal fistula
Climateric changes and associated problems.

UNIT XI
Nursing management of patients with Oncological disorders.
Types of neoplasms and related pathophysiology
Diagnostic procedures
Modalities of treatment and nurse's role
Special therapies- chemotherapy and radiotherapy
Preventive measures, other therapies.

UNIT XII
Nursing management of patient with burns.
Nursing management of patient with reconstructive surgeries.

UNIT XIII
Nursing management of patients with common communicable diseases & STD'S
Nursing management of patients with immunological disorders including HIV/AIDS

UNIT XIV
Nursing management of patients with diseases of eye, ear, nose, throat and skin.

UNIT XV
Nursing management of patients with blood disorders.
Review of anatomy and physiology of blood and blood products
Patho-physiology, diagnostic procedures and management of blood disorders-
Anemia
Leukemia
Bleeding disorders
Hemophilia
Purpura etc.
Blood transfusion , safety checks, procedures and requirements, management of adverse transfusion reaction, records for blood transfusion.
Management and counseling a of blood donors , phlebotomy procedures , and post donation management
Blood bank functioning and hospital transfusion committee.
Bio-safety and waste management in relation to blood transfusion

UNIT XVI
Nursing in medical - surgical emergencies
Cardiac emergencies
Trauma
Poisoning
Crisis management: Thyroid crisis, Hypertension crisis, adrenal crisis.

SUGGESTED READING

1. Brunner& Suddarth 's Textbook of Medical Surgical Nursing 11th Edition, New Delhi; Lippincott. Publication, 2008.

2. Joyce M. Black. Medical Surgical Nursing Clinical Management for Continuity of Care, 5th Edition, India: W.B. Saunders, Company, 1997.

3. Luckman, J. Medical Surgical Nursing- A psycho physiological Approach. 3rd Edition , Philadelphia WB Saunders Publishers.

5. Chintamani " Levis Medical Surgical Nursing 7th Edition , Elsiver 2011

PRACTICAL PAPER I

Medical Surgical Nursing

Time:- 270 Hrs

- Students should be rotated in the selected medical & surgical areas like Cardio-Thoracic, Neurology ,Urology, Orthopedics, ICU, ICCU
- The students should be given patient assignment. They have to practice patient centered comprehensive nursing.
- Each student is required to give planned health teachings,conduct clinical teaching, case presentation and drug study.

Paper IV :- Psychology

Placement: First Year (I Semester) Theory - 60 hrs
Practical-15 hrs

COURSE CONTENTS

UNIT I

* Introduction: Definition of psychology , scope and methods of psychology.
* Relationship with other subjects.

UNIT II

* Sensation, Attention and Perception: Definitions.
* Sensory processes; Normal and abnormal
* Attention and distraction: contributory factors
* Characteristics of perception. Perception: Normal and abnormal

UNIT III

* Motivation : Definition and nature of motivation
* Biological and social motives
* Frustration and conflicts
* Self – actualization

UNIT IV

* Emotions: Definition of emotions, expression and perception
* Emotions in sickness

UNIT V

Personality: Definition, constituents of personality
Personality in sickness and nursing.

UNIT VI

Psychological aspects of nursing.
Behaviour and sickness. Psychological needs of: Child, Adolescents, Adult, Aged,Attendants and Chronically ill individual

UNIT VII

Individual differences, Significance of individual differences, Heredity and environment
Role of individual differences both in health and sickness
Implications of individual differences in nursing.

UNIT VIII

* Intelligence and Abilities : definition
* Intelligence and abilities during sickness.
* Measurement of intelligence and abilities.

UNIT IX

* Learning: definition, Conditions of learning
* Laws of learning
* Learning during health and sickness

UNIT X

* Memory and forgetting: Definition and nature of memory
* Memory during health and sickness
* Forgetting during health and sickness

UNIT XI

* Attitudes : definition, development and modification.
* Role of attitudes in health and sickness

UNIT XII

* Concept of Mental hygiene & Mental health
* Characteristics of a mentally healthy person.
* Defense mechanisms.

Practicum

1. Simple experiments in (i) perception (ii) measuring thresholds (iii) reaction time
2. Administration of psychological tests.
3. Observation and recording data: (I) field observation(ii) interview(iii) case study (iv) self- rating.

Suggested Readings

1. Morgan, C.T. Etal. Introduction to Psychology, 7th Edition., Delhi, Publisher Tata Mcgraw Hill Company Ltd.. 2005.
2. Bhatia and Craig . Elements of Psychology and Mental Hygiene for nurses in India. 26th Impression, Hyderabad, India Publisher orient Longman Pvt. Ltd., 2003.
3. Robert A. Baron. Psychology, (Indian. Ed. LPE) Third impression, New Delhi, Pearson Prentice Hall.2007

Paper V: - Maternal Nursing

Placement: First Year(II Semester) Theory – 60 hrs
Practical- 240 hrs

COURSE CONTENTS

UNIT I
Introduction and historical review
Planning parenthood
Maternal morbidity and mortality rates
Legislation related to maternity benefits , MTP acts , incentives for family planning etc.

UNIT II
Review of the anatomy and physiology of female reproductive system.
Female pelvis (Normal and contracted)
Review of foetal development.

UNIT III
Physiology and management of pregnancy, labour and puerperium.
Signs and symptoms and diagnosis of pregnancy.
Antenatal care

UNIT IV
The New born baby
Care of the baby at birth including resuscitation
Essential New born care
- Feeding
- Jaundice and infections
- Small and large for date babies
- Intensive care of the new born
- Trauma and haemorrhage.

UNIT V
Management of abnormal pregnancy, labour and puerperium
Pregnant women with HIV/ AIDS
Management of common gynecological problems
Abortion, ectopic pregnancy and vesicular mole.
Pregnancy induced hypertension , gestational diabetes, anaemia, heart disease.
Urinary infections. Antepartum hemorrhage

Abnormal labour (Malposition and malpresentation)
- Uterine inertia
- Disorders of puerperium
- Management of engorged breast, cracked nipples, breast abscess and mastitis.
- Puerperal sepsis
- Post partum haemorrhage
- Inversion and prolapse of uterus, obstetrical emergencies
- Obstetrical operations i.e. forceps, vacuum, epistotomy, caesarean section.

UNIT VI
Drugs in obstetrics.
Effects of drugs during pregnancy, labour and puerperium on mother and baby.

UNIT VII
National Welfare Programmes for women, National Family Welfare Programme.
Infertility, Problems associated with unwanted pregnancy, Unwed mothers.

UNIT VIII
Maternal, prenatal and genetic influences on development of defects and diseases
Conditions affecting the mother:- genetic and infections
Consanguinity atopy
Prenatal nutrition and food allergies
Maternal Age
Maternal drug therapy
Prenatal testing and diagnosis
Effect of Radiation, drugs and chemicals
Neural Tube Defects and the role of folic acid in lowering the risks
Down syndrome (Trisomy 21

Suggested Readings:-

OBSTETRICAL NURSING

1. Bennett Ruth V., Myles Text book for Midwives 13th Edition . Churchill Livingstone London , 2001.
2. Dutta D.C. , Text book of Obstetrics , 5th Edition. 2007 , New Central Book Agency Calcutta.
3. Basvanthappa B.T. Midwifery and reproductive Health Nursing. 1st edition, Jaypee Publishers 2006.
4. Wong etal," maternal child Nursing care' 1st edition Mosby Inc., 1998.

GENETIC

1. Lashley Felissa R. essential of clinical Genetics in Nursing Practice, Springer Publishing Company 2007.
2. Lashley Felissa Clinical Genetics in Nursing Practice , 3rd Edition, Springer Publishing company 2005.
3. King Roabert C, " Genetics", 2nd edition, Oxford University Press. 1965.
4. Cohen F.C. ' Clinical Genetics in Nursing' J.B. Lppincot Co Philadelphia
5. Sharma Suresh Kumar," Human Genetics in Nursing' Jaypee Publishing 2006.

PRACTICAL PAPERII:- Maternal Nursing

Practical: - 240 Hrs

Practical Work:-

1. The Students will be posted in:-
   Antenatal clinic, MCH clinic, antenatal ward, labour room, postnatal ward, maternity OT,
   Family welfare department.
   Visit welfare agencies for women and write observation report.
   Follow nursing process in providing care to minimum 3 patients.
   Write at least two nursing case studies and do a presentation.
   Give at least one planned health teaching to a group of mothers.

1. Practice following nursing procedures

   Antenatal, intranatal & post natal examination, and management
   Motivate family for planned parenthood
   Assist in various diagnostic and therapeutic procedures including IUD insertion and removal

Paper VI Child Health Nursing.

Placement : First Year (II Semester)

Theory - 60 hrs
Practical – 240hrs

COURSE CONTENTS

UNIT I

Introduction
Modern concept of child care
Internationally accepted rights of the child
National policy and legislation in relation to child health and welfare.
National programmes related to child health and welfare.
Changing trends in hospital care, preventive pro motive and curative aspects of child health.
Child morbidity and mortality rated.
Differences between an adult and child
Hospital environment for a sick child
The role of a paediatric nurse in caring for a hospitalized child
Principles of pre and post operative care of infants and children.
Paediatric nursing procedures.

UNIT II

The healthy child
Growth and development from birth to adolescence,
The needs of normal children through the stages of development and parental guidance.
Nutritional needs of children & infants, breast feeding supplementary/ artificial feeding and weaning.
Accidents , causes and prevention
Value of play and selection of play material
Preventive immunization

UNIT III

Nursing care of a neonate
Nursing care of a normal newborn
Neonatal resuscitation
Nursing management of a low birth weight baby.
Nursing management of common neonatal disorders.
Organization of neonatal unit, prevention of infections in the nursery.

UNIT IV

Nursing management in common childhood diseases
Nutritional deficiency disorders
Respiratory disorders and infection
Gastrointestinal infections, infestations and congenital disorders
Cardiovascular problem- congenital defects and rheumatic fever.
Genito- urinary disorder- Nephrotic syndrome, Wilms' tumor, infection and congenital disorders
Neurological infections and disorders- convulsions, epilepsy, meningitis, hydrocephalus, spinabifida.
Hematological disorders- Anemias, thalassemia , ITP, Leukemia, Hemophilia
Endocrine disorders- Juvenile Diabetes Mellitus.
Orthopedic disorders- club feet, hip dislocation and fracture.
Disorders of skin eye, and ears.
Common communicable diseases in children their identification, nursing management in hospital and home and prevention.
Paediatric emergencies- poisoning , foreign bodies, haemorrhage, burns and drowning.

UNIT V
Management of behavior disorders in children.
Management of challenged children:-
– Mentally challenged
– Physically challenged
- Socially challenged
Genetic testing in the neonates and children

UNIT VI
Genetic testing in the neonates and children

Screening for
- congenital abnormalities
- Developmental delay
- Dysmorphism

Genetic conditions of adolescents and adults
- Cancer genetics – Familial cancer
- Inborn errors of metabolism
- Blood group alleles and hematological disorder
- Genetic haemochromatosis
- Huntington's disease
- Mental illness

Suggested Readings:-

1. Marlow, Dorthy etall R. Text Book of Paediatrics 6th edition, W.B. Saunder;'s Company, Philadelphia.
2. O.P. Ghai, Essential Pediatrics 6th Edition CBS Publisher and Distributor, New Delhi 2008.
3. Singh Meherban, Care of New Born, 3rd Edition Sagar Publication, New Delhi 1985
4. Wong I. Dona Nursing care of infant and children, Mosby,s 7th Edition
5. Behrman E. Richard, Nelsons Text book of Pediatrics 18th Edition W.B. Saunders Company.

PRACTICAL PAPER III - Child Health Nursing

Practical:- 240 Hrs

The students will:-
- Be posted in paediatric medical and surgical ward, OPD in hospital, Health Centre and Neonatal unit.
- Visit a centre for handicapped children and child welfare center and write observation report.
- Write an observation study of normal children of various age groups in home/ nursery school/ creche
- Follow nursing process in providing care to 3-6 children.
- Write at least two nursing care studies and do a presentation
- Give two planned health teachings, one in hospital and one in OPD/ health centre.
- Practice the following nursing procedures:
- Taking pediatric history.
- Physical assessment of children
- Baby bath
- Feeding
- Restraining
- Calculation of dosage of drugs and administration of medications and injections
- Collection of specimens

- Enema, bowel wash, colostomy irrigation
- Steam and oxygen inhalation
- Preparation to assist with diagnostic tests and operations
- Examination/ Assessment of a newborn
- Neonatal resuscitation
- Care of a baby in incubator and on ventilator
- Photo therapy
- Assist in exchange transfusion and other therapeutic procedures.

PAPER VII ENGLISH (Qualifying)

Placement: First Year (II semester) Theory:- 60 hrs.

COURSE CONTENTS

UNIT I
* Remedial study of grammar
* Review of grammar, vocabulary and effective use of dictionary.
* Prepare task oriented seminars.
* Symposia and panel discussion.

UNIT II
* The ability to understand selected passage and express meaning in one's own words.
* Reading and comprehension of the prescribed books.

UNIT III
* The study of various forms of composition.
* Note taking
* Diary
* Nurse notes, anecdotal records
* Writing of summary
* Nurses reports on health problems
* The student will submit one sample of each item from her own practical experience

UNIT IV
* Verbal communication
*Oral reports
* Summarization of discussion
* Debate
* Listing comprehension- Film, Cassette and Radio.

Suggested Reading:
A text book- cum – workbook consisting of a selection of essay an poems of special interest to students of science and a workbook with exercises on vocabulary(word roots, prefixes, in fixes and suffixes antonyms, etc) grammar and usage, comprehension(inference – drawing, coherence, etc) and composition exercise.

Text Book
1. S. Pit Order, Intermediate English practice book.
2. C.D. Sidhu, An Intensive Courses in English: A Remedial Workbook (Orient Long man, 1978)
3. A. Roy & K.L. Sharma: English for students of science .

GRAMMER BOOKS
1. Longman's simplified English series of late nineteen century and twentieth century writers.

Paper VIII Biochemistry & Biophysics

Placement: First Year (II Semester)

Part A (Biochemistry) - Theory 30 hrs.
Part B (Biophysics) – Theory 30 hrs.

Part A: Biochemistry

Theory -30 hrs

COURSE CONTENTS

UNIT I

* Introduction: Importance of Biochemistry in nursing.
* Study of cell and its various components.

UNIT II

* **Water and Electrolytes: Water** – Sources, property & functions in human body.
* Water and fluid balance.
* Electrolytes of human body, functions, sources.

UNIT III

* Enzymes
  - Mechanism of action
  - Factors affecting enzyme activity.
  - Diagnostic applications
  - Precautions for handling specimens for enzyme estimation
* Digestion and absorption of carbohydrates, proteins and fats
* Various factors influencing the digestion and absorption , mal-absorption syndrome.

UNIT IV

* Carbohydrates: Catabolism of Carbohydrates for energy purposes
* TCA &Oxidation Phosphorylation.
* Fates of glucose in the body:- Maintenance of blood glucose levels and its regulation.
* Glucose tolerance test, hyperglycemia, hypoglycemia.

UNIT V

- **Protein:**

* Digestion and absorption of proteins
* Amino acids:-Essential & Nonessential.
* Bio synthesis of protein in the cells
* Nitrogenous constituents of Urine , Blood, their origin- urea cycle , uric acid formation , gout.
* Plasma proteins and their functions.
* Hormones.

UNIT VI

- **Fat:**

* Digestion and absorption of fats.
* Bio synthesis of fats and storage of fats in the body.
* Role of liver in fat metabolism.
* Biological importance of important lipids and their functions.
* Cholesterol and lipoprotein.

- Sources, occurrence and distribution.
- Blood level and metabolism
- Ketone bodies and utilization.

* Inter- relationships in metabolism and cellular control metabolic processes.

Suggested Readings:-

1. Satyanarayan,' Essentials of Bio chemistry' IInd Edition, Kolkata India, SIMCE Publications, 2002.
2. Reddy, Medical Biochemistry for Nurses' IInd Edition, Daryanganj New Delhi, Jaypee Publications 2008.
3. Malhotre V.K. ' Biochemistry s for students' XIth Edition, Daryanganj, New Delhi, Jaypee, Publications.
4. Holum John R. ' Fundamental of General, Organic and Biological Chemistry' John Wiley & Son, Inc .USA, 1978.
5. Jacob, Anthikad, Biochemistry for Nurses 2nd Edition, Daryanganj, New Delhi, Jaypee Publications, 2004

Part B: Biophysics

Theory: 30 hrs.

COURSE CONTENTS

UNIT I

* Introduction: concepts of unit and measurements.
* Fundamental and derived units
* Units of length, weight, mass, time.

UNIT II

* Vector and scalar motion, speed, velocity and acceleration.

UNIT III

* Gravity: specific gravity, center of gravity, principles of gravity.
* Effect of gravitational forces on human body.
* Applications of principles of gravity in nursing.

UNIT IV

* Force, Work, Energy: Their units of measurement.
* Type and transformation of energy, forces of the body, static forces.
* Principles of machines, friction and body mechanics.
* Simple mechanics- lever and body mechanics, pulley and traction, incline plane, screw.
* Applications of these principles in nursing.

UNIT V

* Heat: Nature, measurement, transfer of heat.
* Effects of heat on matter.
* Relative humidity, specific heat
* Temperature scales
* Regulation of body temperature
* Use of heat for sterilization
* Application of these principles in nursing

UNIT VI

* Light: Laws of reflection
* Focusing elements of the eye, defective vision and its correction, use of lenses
* Relationship between energy, frequency and wavelength of light
* Biological effects of light
* Use of light in therapy
* Application of these principles in nursing

UNIT VII

* Pressures: Atmospheric pressure, hydrostatic pressure, osmotic pressure
* Measurements of pressures in the body
    - arterial and venous blood pressures
    - ocular pressure
    - intracranial pressure
    - application of these principles in nursing

UNIT VIII

* Sound: Frequency, Velocity and Intensity
* Vocalization and hearing.
* Use of ultrasound, Noise pollution and its prevention
* Application of these principles in nursing

UNIT IX

* Electricity and Electromagnetism: Nature of Electricity, Voltage, Current, Resistance and their Units
* Flow of electricity in solids, electrolytes, gases and vacuum
* Electricity and human body
* ECG, EEG, EMG, ECT
*
* Pace makers and defibrillation
* Magnetism and electricity.
* M.R.I. Scanning, CAT scan

UNIT X

* Atomic Energy: Structure of Atom, Isotopes and Isobars
* Radioactivity: Use of radioactive isotopes
* Radiation protection units and limits , Instruments used for detection of Ionizing radiation, X-rays

UNIT XI

* Principles of Electronics: common electronic equipments used in patient care.

Practicum

* Experiments and Tests to be demonstrated wherever applicable.

Suggested Reading:-

1. Inamdar Madhuri, Applied Physics in Nursing
2. Venkatesh, G., Physics for Nurses
3. Naik,Sanjeev., Applied Physics for Nurses
4. Sharma, Sursesh.Bio-Physics in Nursing

Paper IX :- Mental Health Nursing

Placement : Second Year(III semester) Theory- 60 hrs.
Practical- 240hrs.

COURSE CONTENTS

UNIT I

* Introduction and Historical development.
* History of psychiatry.
* Historical development of mental health nursing.
* Philosophy , Principles of mental health and psychiatric nursing
* Concept of normal and abnormal behaviour
* Role and qualities of mental health and psychiatric nurse
* Mental health team and functions of team members.
* Legal aspects in psychiatry and mental health services.

UNIT II

* Classification and assessment of mental disorders.
* Terminologies used in psychiatry.
* Etiological factors and psychopathology of mental disorders.
* History taking and assessment methods for mental disorders.

UNIT III

* Communication process
* Therapeutic communication & techniques of communication.
* Interview skills, Nurse patient relationship. Therapeutic impasse and its management
* Process recording.

UNIT IV

* Management of mental disorders.
* Etiological factors, psychopathology, types, clinical features, diagnostic criteria, treatment and nursing management of patient with following disorders:

- Neurotic Disorders: Anxiety Neurosis, Depressive Neurosis, Obsessive Compulsive Disorder, Phobic Neurosis and Hypochondriacal Neurosis. Stress related and Somato form disorders.
- Psychotic disorders: Schizophrenia , Bipolar affective Disorder and Organic Psychosis.
- Organic Brain syndromes
- Psychosomatic disorders
- Personality disorders.
- Disorders of childhood and adolescence.

UNIT V

* Management of patient with substance use disorders
* Substance use disorder
* Dependence , intoxication and withdrawal
* Classification of psychoactive substances
* Etiological & contributory factors
* Psychopathology
* Clinical features
* Diagnostic criteria

* Treatment and nursing management of patient with substance use disorders.
* Preventive and rehabilitative aspects in substance abuse

UNIT VI

* Management of mental sub- normality
* Classification of mental sub-normality.
* Etiological factors, psychopathology, psychometric assessment, diagnostic criteria and management of mental sub- normality.

UNIT VII

* Psychiatric emergencies
* Types of emergencies, psychopathology, clinical features, assessment and diagnosis, treatment and nursing management of patient with psychiatric emergencies
* Crisis intervention .

UNIT VIII

* Therapeutic modalities
* Principles, indication, contraindications and role of nurse in various treatment methods:
  - Therapeutic community and Milleu therapy
  - Occupational therapy
  - Psychotherapy
  - Behaviour therapy
  - Group therapy
  - Family therapy
  - Pharmacaltherapy
  - Electro convulsive therapy
  - Other miscellaneous therapies.

UNIT IX

* Preventive psychiatry
* Model of prevention
* Role of nurse in preventive psychiatry
* Psychiatric social work
* Community mental health nursing
* Community mental health agencies
* National mental health programme

Suggested Reading:-

1. Stuart, G.W. And Laraia, M.T. Principles and practice of Psychiatric Nursing 8th Edition, India: Elesiver, 2008.
2. WHO, ICD-10 Classification of mental and Behavioural disorders Geneva 2007.
3. Kapoor Bimla, Text book of Psychiatry Nursing . Vol I and II, 2nd edition , New Delhi, Kumar Publishing House , 2001
4. Townsend, M, Psychiatric Mental Health Nursing Concepts of Care in Evidence based practice, 5th Edition N.D. Jaypee Brother, 2007.
5. Shives, Basic Concepts in Mental Health Nursing, 2nd Edition, Philadelphia: J B Lippincott1990.

PRACTICAL PAPER IV - Mental Health Nursing

Time:-240 Hrs.

PRACTICAL:-

The student will be provided opportunity to:

- Observe, Record and report the behavior of their selected patients.
- Record the process of interaction.
- Assess the nursing needs of their selected patients, plan and implement the nursing intervention.
- Counsel the attendant and family members of patient.
- Participate in the activities of psychiatric team.
- Write observation report after a field visit to the following places:

– Child guidance clinic
– School/ special schools (For mentally subnormal)
– Mental Hospital.
– Community Mental Health centres
– De- addiction centre.

Paper X :- SOCIOLOGY

Placement: Second Year (III Semester)   Theory: 60 hrs

COURSE CONTENTS

UNIT I

Introduction
Importance of study of sociology in nursing, relationship of anthropology , sociology etc.

UNIT II

Individual and the society
Socialization
Interdependence of the individual and society
Personal disorganization

UNIT III

Culture
Nature of culture
Evolution of culture
Diversity and uniformity of culture.

UNIT IV

Social organization
Social groups, crowds and public groups, nations, race.
Social institution: The family , marriage, education, religion, arts, economic organization, political organization.
The urban and rural community in India: Ecology, characteristics of the village, characteristics of the town and city.
Social stratification: Class and caste.

UNIT V

Social Process
Process of Social Interaction: Competition, conflict- war cooperation, accommodation and assimilation.

UNIT VI

Social change
Nature and process of Social Change: Factors influencing cultural change, Cultural lag.

UNIT VII

Social problems
Social disorganization, control and planning: poverty, population housing, illiteracy, food supplies, growth of urbanization, prostitution, minority groups , rights of women & children, child labour, child abuse, delinquency and crime, substance abuse.

Sociology

Suggested Reading:-

1. Sachdeva D.R. And Vidhya Bhushan An Introduction to Sociology: Kitab Mehal.
2. Madan G.R. Indian Social Problems- Vol. I Allied Publishers Ltd.

3. Neereja K.P. Test book of Sociology for Nursing Students Jaypee Brothers, Medical Publications (P) Ltd.
4. Sanjay Bhattacharya, Social Work- An Integrated Approach Deep & Deep Publication (P) Ltd.
5. Kapadia K.M. Marriage and Family in India: Oxford University Press.

Paper XI:- Introduction to Nursing Research and Statistics

Placement: Second Year (III semester)

Theory - 60 hrs.
Practical - 120 hrs.

COURSE CONTENT

A. INTRODUCTION TO RESEARCH METHODOLOGY

UNIT I

* Steps of Scientific methods
* Definition of Research
* Need for Nursing Research
* Characteristics of good research. Research Process.

UNIT II

* Statement of research problem
* Statement of purpose and objectives
* Definition of research terms
* Review of literature.

UNIT III

* Research approaches:- historical, survey and experimental

UNIT IV

* Sampling Techniques and methods of data collection
* Sampling
* Instruments – Questionnaire , Interview
* Observation schedule, records, measurements
* Reliability and validity of instruments.

UNIT V

* Analysis of Data: Tabulation
* Classification and summarization
* Presentation and Interpretation of data.

UNIT VI

* Communication of research findings
* Writing Report:
    - Organizing materials for writing
    - Format of the report
    - Use of computers.

B. INTRODUCTION TO STATISTICS

UNIT VII

Descriptive Statistics.
Frequency Distribution- Types of measure- frequencies, class interval, graphic methods of describing frequency
Measures of Central Tendency- mode, median and mean
Measures of Variability: Range, standard deviation
Introduction to normal probability.

UNIT VIII

Correlation
Computation by rank difference methods.
Uses of correlation co- efficient.

UNIT IX

Bio-statistics: Crude rates and standardized rates, ratio and estimation of the trends.

UNIT X

Introduction to computers in nursing
Introduction to computers and disk operating system.
Introduction to word processing
Introduction to data base.
Windows application, word, excel, power point, multimedia.
Use of statistical packages.
Introduction to internet & Use of electronic mail
Computer aided teaching & testing.

Practical

Students will conduct research project in small groups in selected areas of nursing & submit a report (Group studies may include studying of existing health practices, improved practices of nursing (procedures), health records, patient record & survey of nursing literature).

SUGGESTED READINGS

NURSING RESEARCH

1. Polit D & Hungler B. Nursing Research Principles and Methods. 6th Edition, Lippincott Williams & Wilkins, 1999.
2. Nancy Burns and Suan K. Grove Understanding Nursing Research, WB Saunders Co. 1995.
3. Treece E.W. & Treece J.W. Elements of Research in Nursing, 4th Edition, C.V. Mosby Co.1986.
4. Nieswiadomy R.M. Foundations of Nursing Research 5th Edition India Pearson education 1993.
5. Best J.W. & Kahn J.V. Research in Education , 9th Edition, Pearson Education, 2003.

STATISTICS

1. Henry E. Garrett, Statistics in Psychology and education: Paragon International Published, 12th Edition. Reprint 2005-2007
2. Sidney Seigel, N.J. Castella Jr. Non Parametric Statistics: 3rd Edition, Mc Graw Hill Book Company 2000.
3. Barbara Hazand Micro, Statistics Methods for Health care Research: 5th Edition, Cippincott Willams & Wilicias, 2005.
4. Negi K.S. , Bio statistics: A.I.T. B.S. Published & Distribution, Delhi, 2005.
5. Kumar Jyoti, Bio statistic: A.I.T.S publication 1st Edition, 2005.

Paper XII:-Introduction to Nursing Administration

Placement: Second Year (III Semester)

Time Allotted: Theory - 60 hrs
Practical- 180hrs

COURSE CONTENTS

UNIT I

Principles and Practice of Administration
Significance, elements and principles of administration
Organization of Hospital- Definition , aims, functions and classifications , health team.
Policies of Hospital, different department with special emphasis to department of nursing & office management
Responsibilities of the nursing personnel specially of ward sister, medico legal aspects, concept of cost effectiveness.

UNIT II

Nursing unit management, Physical layout of a nursing unit and necessary facilities, factors affecting the quality of nursing care.
Maintenance of a therapeutic environment
Administration of the unit – management of patient care.
Maintenance of physical environment
Assignment of duties and time plan.
Patient assignment , safety measures, prevention of accidents and infections
Maintenance of patients record and reports , legal responsibilities
Maintenance of quality nursing care, nursing audit.

UNIT III

Personal management
Staff recruitment and selection , appointment, promotions, personnel policies and job descriptions.
Job analysis
Staffing the unit , staffing norms, rotation plan, leave planning, performance appraisal, staff welfare and management of disciplinary problems.

UNIT IV

Supervision
Principles of supervision, nature and objectives
Tools and techniques of supervision
Evaluation
Nursing audit
Staff development- orientation program
Skill training
Leadership development
Problem solving process.

UNIT V

Material management
Principles of material management.
Quality control
Inventory, care of equipment, safekeeping
Role of nursing personnel in material management

UNIT VI

Financial management

Budgeting- principles of budgeting audit.

UNIT VII

Organizational Behaviour
Group dynamic and human relation, organizational communication (hospital information system)
Public relations, leadership styles and functions.
Methods of reporting
Maintaining records and reports.

Practical

Observe the functioning of nursing administration at various level i.e. institution, department & unit.
Each student will practice ward management under supervision.
Student will prepare rotation plan of the staff, write reports, give verbal reports of the ward & assist in maintaining the inventory of the nursing unit.
Visit to Private & Government hospital & write observation reports.

SUGGESTED READINGS

1. T N A I , **Nursing Administration & Management**; 1st Edition: 2000
2. Awasthi and Maheshwari, " Public Administration', Lakshmi Narayan Aggarwal educational Publishers, Agra.
3. Barvett, Jean, " Ward Management and Teaching" 13th Re-print, Konark Publisher Pvt.Ltd. 2002, Delhi.
4. Goyal R.C. ' Hospital Administration and Human Resource Management" Prentice Hall of India Pvt. Ltd. New Delhi 2005

Paper XIII:- HEALTH/ NURSING INFORMATICS & FORENSIC NURSING

Placement: Second Year (III Semester) Time Allotted: Theory - 15 hrs

PART –A HEALTH/ NURSING INFORMATICS

COURSE CONTENTS

UNIT -I

Introduction to computer applications for patient care delivery system and nursing practice(Revision)

- Use of computers in teaching, learning, research and nursing practice
- Hospital management information system

UNIT -II

Principles of Health Informatics

- Health informatics – needs, objectives and limitations
- Use of data, information and knowledge for more effective healthcare and better health

UNIT -III

Electronic Health Records

- Challenges of capturing rich patient histories in a computable form
- Latest global developments and standards to enable lifelong electronic health records to be integrated from disparate systems.

UNIT -IV

Patient Safety & Clinical Risk

- Relationship between patient safety and informatics
- Function and application of the risk management process

UNIT -V

Clinical Knowledge & Decision Making

- Role of knowledge management in improving decision-making in both the clinical and policy contexts
- Systematized Nomenclature of Medicine, Clinical Terms, SNOMED CT to ICD-10-CM Map, standardized nursing terminologies (NANDA, NOC), Omaha system.

UNIT -VI

eHealth: Patients and the Internet

- Use of information and communication technology to improve or enable personal and public healthcare
- Introduction to public health informatics and role of nurses
- Use of Statistical packages.

UNIT -VII

Using Information in Healthcare Management

- Components of Nursing Information system (NIS)
- Evaluation, analysis and presentation of healthcare data to inform decisions in the management of health-care organizations.

UNIT -VIII

Information Law & Governance in Clinical Practice

- Ethical-legal issues pertaining to healthcare information in Contemporary clinical practice
- Ethical-legal issues related to digital health applied in nursing

UNIT -IX

Healthcare Quality & Evidence Based Practice

- Use of scientific evidence in improving the quality of healthcare and technical and professional informatics standards

PART –B INTRODUCTION TO FORENSIC NURSING AND INDIAN LAWS

Placement: Second Year (III Semester) Time Allotted: Theory - 15 hrs.

COURSE CONTENTS

UNIT –I

Forensic Science
- Definition
- History
- Importance in medical science
- Forensic Science Laboratory

UNIT –II

Violence
- Definition
- Epidemiology
- Source of data

Sexual abuse – child and women

UNIT –III

Forensic Nursing
- Definition
- History and development
- Scope – setting of practice, areas of practice and subspecialties
- Ethical issues
- Roles and responsibilities of nurse
- INC & SNC Acts

Forensic Team
- Members and their roles

UNIT –IV

Comprehensive forensic nursing care of victim and family
- Physical aspects
- Psychosocial aspects
- Cultural and spiritual aspects

- Legal aspects
- Assist forensic team in care beyond scope of her practice
- Admission and discharge/referral/death of victim of violence
- Responsibilities of nurse as a witness

UNIT –V

Evidence preservation – role of nurses
- Observation
- Recognition
- Collection
- Preservation
- Documentation of Biological and other evidence related to criminal/traumatic event
- Forwarding biological samples for forensic examination

UNIT –VI

Introduction of Indian Constitution Fundamental Rights
- Rights of victim
- Rights of accused

Human Rights Commission Sources of laws and law-making powers

UNIT –VII

Overview of Indian Judicial System
- JMFC (Judicial Magistrate First Class)
- District
- State
- Apex

Civil and Criminal Case Procedures
- IPC (Indian Penal Code)
- ICPC
- IE Act (Indian Evidence Act)

Overview of POSCO Act

Paper XIV:- Community Health Nursing

Placement: Second Year (IV Semester)   Theory - 60 hrs.
Practical- 240 hrs.

COURSE CONTENTS

UNIT I

* Introduction
* Introduction to Community Health - Concepts, Principles and Elements of Primary Health Care.
* Introduction to Community Health Nursing.
* Concepts of Community Health Nursing- community nursing process
* Objectives, scope and principles of community health nursing.

UNIT II

* Family Health services
* Concepts, objectives, scope and principles
* Individual, family and community as a unit of service
* Principles and techniques of home visiting.
* Establishing working relationship with the family
* Working with families in relation to prevention of disease, promotion of health
* Care of the sick in the home, physically handicapped and mentally challenged.
* Surveillance and monitoring.

UNIT III

* Organization and administration of health services in India.
* National Health Policy.
* Health care delivery system in India.
* Health team concept
* Centre, state, district, urban health services , rural health services.
* System of medicines
* Centrally sponsored health schemes,
* Role of voluntary health organization and international health agencies.
* Role of health organization and international health agencies.
* Role of health personnel in the community.
* Public health legislation.

UNIT IV

* Health Education
* Aims, concepts and scope of health education
* National plan for health education
* Communication techniques.
* Methods and media for health education programmes.
* Planning for health education and role of nurse.

UNIT V

* Role of the community health nurse
* National health programmes.
    - Maternal and child health progammes.
    - Family welfare and school health services.
    - Occupational health team.
* As a member of the health team.
* Training and supervision of health care workers.

UNIT VI

Epidemiology
Definition- Concepts, aims, objectives, methods, principles
Epidemiology- Theories and models.
Application of epidemiology, principles and concepts in community health.

UNIT VII

Bio statistics and vital statistics.
Introduction, definition and scope, legislation.
Report , recording and compiling of vital statistics at the local, state, national and international level.
Definitions and methods of computing vital statistics.
Methods of presenting data
Management Information System

SUGGESTED READING

1. J.E., Textbook of preventive and Social Medicine . Edition, Jabalpur, Banarsidas Bhanot Publishers, 2011.
2. Gulani, Krishna Kumari, Community Health Nursing Principles and Practices. First Edition, Delhi: Kumar Publishing House, 2006.
3. Patney, Sunita., Text Book of Community Health Nursing: First Edition Delhi: Modern

Publishers, 2005.
4. Stanhope , M. and Lancaster. J. community Health Nursing: Process and practice for promoting Health. 3rd Edition Toronto : Mosby Year Book.
5. Rao, Dr (Mrs) K.S, An Introduction to Community Health Nursing, 3rd Edition, Chennai, B.I., Publications, 2002.

PRACTICAL PAPER V – Community Health Nursing

Practical – 240

Practical work:-

- Each student will prepare a community profile.
- The students will be allotted families for gaining experience in identifying family health needs, health counselling and guidance and family budgeting for optimum health.
- The students will participate in the activities of Primary Health Centre, Sub-centre, MCH centre.
- Visits will be made to selected health and welfare agencies , water purification plant and sewage disposal plant, infectious disease hospital.
- Conduct Health Education programmes for individual/ groups/ community.

Paper XV :- Introduction to Nursing Education

Placement: Second Year (IV Semester)

Theory - 60 hrs
Practical - 180 hrs

COURSE CONTENTS

UNIT I

Introduction to Education.
Meaning of Education, aims, function and principles.
Philosophy of Education
Factors influencing development of Philosophy of nursing education.

UNIT II

Teaching learning process
Nature and characteristics of learning
Principles and maxims of teaching
Formulating objectives
Lesson planning.

UNIT III

* **Methods of teaching**
-Lecture, Discussion, Demonstration, Group discussion, Project, Role Play, Panel discussion, Symposium, Seminar Field trip, Workshop, Exhibition, Programmed instruction, Computer assisted learning

* **Clinical teaching methods:**
Case method, Case presentation, Nursing rounds and reports, Bedside clinic, Conference (Individual and group)
-Recording of interaction process.

UNIT IV

* Educational media
* The communication process , factors affecting communication.
* Purposes and types of audio visual aids
* Graphics aid: chalk – board, charts, graphs, posters, flash cards, flannel graph/ khadigraph, bulletin,cartoon
* Three dimensional aids: objects, specimen, models, puppets.
* Printed aids: pamphlets and leaflets
* Projected aids: slides, films and televisions, VCR, VCP, overhead projector, camera, microscope.
* Audio-aids : tape- recorder, public address system, computer.

UNIT V

Methods of assessment
Purpose and scope of evaluation and assessment.
Criteria for selection of assessment techniques and methods.
Assessment of knowledge: essay type question, SAQ (short answer questions)
MCQ (multiple choice questions)
Assessment of skills: Observation, Check list, Practical examination, Viva, Ojective structured clinical examination
Assessment of attitude : Attitude scale.

UNIT VI

Management of School of Nursing.
Planning of school of nursing , organization
Recruitment of teaching staff, budget, facilities for the school, student selection and admission procedures, administrative planning for students , welfare services for students, maintenance of school records, preparation of annual reports. INC guidelines for school of nursing.

UNIT VII

Guidance and counseling , definition
Basic principles of guidance and counseling
organization of guidance and counseling services.
Counseling process
Managing disciplinary problems
Management of crisis.

UNIT VIII

In- service education
Introduction to nature and scope of in service education programme.
Principles of adult learning
Planning for in- service programme.
Techniques, and methods of staff education programme
Evaluation of in- service programme.

Suggested Reading:-

1. Heidgerken, E. Loretta," Teaching & Learning in Schools of Nursing" 15th Re-print Konark Publishers, 2006.
2. Bhatia K & Bhatia B.D., " The principles and Methods of Learning" DOABA HOUSE,1994, Nai sarak, New Delhi.
3. Neeraja K.P. " Test book of Nursing Education" Jaypee Brothers, New Delhi, 2007

Annexure-6

Bachelor of Life Science (Program)

SEMESTER VII

UNIVERSITY OF DELHI

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VII

Under UGCF-2022 based on NEP-2020

(Effective from Academic Year 2022-23)

Department of Botany

Courses offered in B.Sc. Life Science Semester VII with Botany as Major Discipline (course contents)

SEMESTER –VII

(Under UGCF-2022 based on NEP-2020)

DISCIPLINE SPECIFIC COURSE (DSC-07)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Environmental Biotechnology & Management **LS-DSC-BOT-07**	**4**	**2**	**0**	**2**	Sem VI	**Nil**

COURSE LEARNING OBJECTIVES:

The course aims to build awareness of:

- various global and regional environmental concerns due to natural causes and/or human activities.
- different types of pollution and their impacts on the environment.
- existing and emerging technologies that are important in the area of environmental biotechnology to fulfill Sustainable Development Goals.

LEARNING OUTCOMES:

After completion of course the student will be able to:

- demonstrate awareness about emerging concerns such as climate change, waste management; biodegradation of xenobiotic compounds; bioremediation, etc.
- relate applications of biotechnology for alleviating the environmental concerns
- appreciate the scientific, ethical and/or social issues
- understand the national and international legislations, policies and role of public participation in Environmental Protection

THEORY: 30 HOURS

Unit 1: Environment (5 hours)

Basic concepts and issues, global environmental problems - ozone layer depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management. Fate of pollutants in the environment, Bioconcentration, Biomagnification.

Unit 2: Microbiology of waste water treatment (7 hours)

Aerobic process - activated sludge, oxidation ponds, trickling filter. Anaerobic process - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy and sugar industries.

Unit 3: Xenobiotic compounds and Treatment of toxic compounds, Role of immobilized cells/enzymes, microbial remediation (12 hours)

Organic (Bio degradation of petroleum products and pesticides) and inorganic (metals, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, Bioaccumulation and Biosorption of metals, Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. Bioindicators and Bioprospecting.

Unit 4: International Legislations, Policies for Pollution Management and Environmental Protection (6 hours)

Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Kyoto Protocol- 1997. Environmental ethics, Water Pollution (Prevention and Control) Act-1974, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy - 2006, Central and State Pollution Control Boards: Constitution and power.

PRACTICALS: (60 hours)

1. To determine the pH and total hardness of water samples collected from different places (polluted and non-polluted sites)
2. To determine the salinity of water samples (polluted and non-polluted sites)
3. To determine the dissolved oxygen of two water samples.
4. To determine the alkalinity of water samples.
5. To determine the pH and rapid field test of soil samples (Chloride, Nitrate, and Sulphate).
6. To study microbessuspended in air and water samples.
7. A visit to any educational institute/ industry to understand the uses of microbes in environmental management and a report to be submitted for the same.

SUGGESTED READINGS:

1. De, A. K. (2022). Environmental Chemistry, 10th Edition, New Delh i. New Age International Pvt. Limited
2. Dennis, A., Seal, K.J., Gaylarde, C.C. (2004). Introduction to Biodeterioration, Cambridge University Press
3. Ahmed, N., Qureshi, F.M., Khan, O.Y. (2006). Industrial and Environmental Biotechnology, Horizon Press
4. Rochelle, P.A. (2001). Environmental Molecular Biology, Horizon Press.
5. Jadhav, H.V., Bhosale, V.M. (2015). Environmental Protection and Laws, Himalaya publishing House Pvt Ltd.
6. Trivedi, P. C. (2006). Biodiversity Assessment and Conservation, Agrobios Publ.
7. Rana, S.V.S. (2015). Environmental Biotechnology, Rastogi Publications, India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -08: Research Methodology **CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RESEARCH METHODOLOGY BOT-DSE -08	4	**2**	**0**	**2**	Semester VI	Nil

COURSE LEARNING OBJECTIVE:

This course offers overview of Research Methodology including quantitative and qualitative research in basic as well as applied aspects of Biological Sciences. It is designed to provide hands-on experience with collection, analysis and interpretation of data and also writing a report/thesis. Moreover, this course focusses on developing the skills necessary for pursuing a career in research. The students will be motivated to learn scientific investigation to solve problems, test hypothesis, develop or invent new products for the benefit of society.

COURSE LEARNING OUTCOME:

After completing this course, the students should be able to:

- describe basic concepts of research and its methodologies
- identify appropriate research topics and propose hypothesis
- perform literature review using library (print) and internet (online) resources
- design experiments/surveys
- collect, analyze and interpret data with appropriate software tools, represent data in tables/figures and draw conclusion
- write scientific report/ review/ thesis and prepare seminar/ conference presentations
- understand the methods of citation and referencing styles, check plagiarism and get insight of intellectual property rights

THEORY: 30 Hours

Unit 1: Basic Concepts of Research (4 Hours)

Objectives, Research Methods vs Methodology, Types of Research-Quantitative vs Qualitative, Analytical vs Descriptive, Basic vs Applied, Field Research, Search engines, Literature-review and its consolidation

Unit 2: Research Design, Data Collection and Analysis (12 Hours)

Conceptualization a research problem, Developing a research model, Validation of the proposed model with standard procedures and attributes, Experimental design, and implementation, Observation and Data acquisition, Methods of data collection, Data quality check, Processing and Analysis Strategies; Data presentation (Tables and Figures), Interpretation

Unit 3: Ethical Issues **(4 Hours)**
Intellectual Property Rights, Copy Right, Plagiarism, Commercialization and Royalty

Unit 4: Report Writing **(10 Hours)**
Technical Research writing (Dissertation/ Reports/Research/Review papers), Citations, Acknowledgements, Research Grants/ Fellowships, Bibliography

PRACTICALS: **60 Hours**

1. Search engines, Literature survey, identification of gap areas
2. Presentation of collated literature
3. Experimental layout, execution, observation
4. Data analysis, using softwares, tables and figures
5. Writing a report/research paper/dissertation/summary
6. Preparation of bibliography in different formats as per journal's requirements
7. Usage of software tools for checking plagiarism

Assessment Methods:
Submission and presentation of thesis/Dissertation followed by viva-voce

SUGGESTED READINGS:

1. Coley, S.M. and Scheinberg, C.A. (1990). "Proposal writing". Stage Publications.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Wadhera, B.L. (2002). Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, Universal Law publishing.
4. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
5. Anthony, M, Graziano, A.M. and Raulin, M.L. (2009). Research Methods: A Process of Inquiry, Allyn and Bacon.
6. Kothari, C.R. (2014). Research Methodology: Methods and Techniques, 2nd edition, New Age International (P) Ltd.,
7. Walliman, N. (2011). Research Methods- The Basics. Taylor and Francis, London, New York, USA.
8. Cresswell, J.W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th edition). SAGE Publications Inc.
9. Rao, G.N. (2018). Biostatistics & Research Methodology. Pharmamed Press.
10. Gary J. Burkholder, G.J., Cox, K.A., Crawford, L.M. Hitchcock, J.H. (2019). Research Design and Methods: An Applied Guide for the Scholar-Practitioner. SAGE Publications, Inc.
11. Mukherjee, S.P. (2019). A Guide to Research Methodology: An Overview of Research Problems, Tasks and Methods. CRC Press
12. Flick, U. (2020). Introducing Research Methodology: Thinking Your Way Through Your Research Project. SAGE Publications Ltd.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 09: Biodiversity Informatics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biodiversity Informatics **BOT-DSE-09**	4	**2**	**0**	**2**	Semester VI	Nil

COURSE LEARNING OBJECTIVES: To introduce students to an integrated area of study where concepts learnt under different courses in previous semesters are to be utilised. The field of Biodiversity informatics integrates information on systematics, ecosystems to curate, analyse and develop an information management system to provide sound scientific bases for policy decisions.

LEARNING OUTCOMES:

- **Assess** knowledge on basic principles of Ecology, Conservation, Restoration, Biodiversity, Genetics, Molecular biology.
- Applications of Remote Sensing and Geographical Information System as well as Informatics.
- Provide an opportunity to learn principles of Data Capture systems, basic elements of digitisation of Biological data, some key elements of Information Science along with creation/ curation of Biological Databases (collection, storage & retrieval)
- Emphasise the importance of field collection, maintenance of herbaria & specimen collections.
- Introduce relevant National and International Biodiversity Laws.

THEORY: 30 Hours

Unit 1. History of Biodiversity Informatics and Informatics Resources (08 Hours)

I. Global & National movements for conservation, institutions (including National Biodiversity Authority of India, NBPGR and others) and other non-Governmental organisations (NGO s) and networks involved in biodiversity informatics.

II. National & International efforts in Conservation, databases GBIF, IUCN categorized-endangered, threatened, vulnerable species.

III. Red data book and related documentation.

IV. Categories of Biodiversity informatics databases and tools based on target life cycle step : data planning and collection, data quality and fitness, data description, data preservation and publication, data discovery and integration, computational modeling and analysis.(few databases example can be chosen to explain the steps - BRAHMS, Genbank, Catalog of Life, DataOne, GBIF, BioCollections)

Unit 2. Understanding Biodiversity and Measuring/Estimating Biodiversity (11 Hours)

i. Recapitulating Basic principles of Ecology & Biodiversity - Geological Time scale and evolution of life forms, Five major extinctions, Ecosystems & Ecosystems diversity: biomes, mangroves, coral reefs, wetlands and terrestrial diversity. Biodiversity Hotspots & factors of endemism.
ii. Levels of Biodiversity: Community diversity (alpha, beta and gamma biodiversity), Gradients of Biodiversity (latitudinal, insular).
iii. Magnitude of biodiversity (Global and Indian data). Introduction to Diversity Indices (Simpson, Shannon) and estimation of Species diversity: richness and evenness, loss of species.
iv. Metagenomics, use of ancient DNA (aDNA) for estimation of biodiversity loss.
v. Estimating Threats to natural Biodiversity: Habitat loss and fragmentation
vi. Disturbance and pollution; Introduction of exotic species; Human intervention and Biodiversity loss; Consequences of monotypic agricultural practice
vii. Global Environmental changes, land and water use changes ; Impacts of Climate Change on Biological systems.

Unit 3 – Methods In Biodiversity Informatics (05 Hours)

i. Remote Sensing/ Geographical Information Systems and its applications.
ii. Data capture – citizen science, uploading information on portals (e.g. www.indiabiodiversityportal.org).
iii. Key parameters for conservation (populations reproductive ecology)
iv. Essential management practices in in-situ and ex-situ Biodiversity Management :
    a. Management of - Biosphere reserves, National Parks, Sanctuaries, Sacred groves etc.
    b. Management of Botanical gardens, Zoological gardens, Gene banks, Pollen, seed and seedling banks, tissue culture and DNA banks etc.

Unit 4. Applications of Biodiversity Informatics (06 Hours)

i. Modeling Ecosystems & Predictions, conservation plans for species/taxa/ecosystem.
ii. Definitions and concepts of system, sub-system, variables and parameters, systems analysis, modeling and simulation ((Lotka-Voltera model).
iii. Legal issues in Biodiversity Management & Conservation; Rules for exchange of genetic materials; Case studies -National & International. (This is important for IPR perspective, gives the student and faculty options for assignments/ assessments, case studies
iv. Legal issues in Biodiversity Management & Conservation; Rules for exchange of genetic materials; Case studies -National & International.
v. Designing & implementing ecological restorations.

PRACTICALS: **(60 hours)**

1. Measurement of species diversity (calculation of Diversity Indices - from data collected on plant species in different areas of the campus.
2. Use of molecular markers for estimating biodiversity (DNA Barcoding).
   (simple case studies and wherever possible experiments can be performed to teach the concept).
3. Blast analyses of selected DNA sequences from the International Gene Banks.
4. Introduction to simulations based on various environmental models.
5. Applications of RS/GIS techniques for species distribution models.
6. **Experiential Learning Module**: Visit to Biodiversity Parks, study the management and species diversity, based on that prepare a proposal for enhancement/ creation of local Biodiversity Park/Community outreach activities and other attributes.

SUGGESTED READINGS:

1. Groom MJ, Meffe GK, Carroll CR (2006) Principles of Conservation Biology, 3rd edition, Sinauer Associates.
2. Tandon U, Parasaran M, Luthra S (2018) Biodiversity : Law, Policy and Governance, Routledge, India
3. Wilson, Edward O., 1993, Diversity of Life. Harvard University Press, Cambridge, MA.
4. Wheater CP, Bell JR, Cook PA (2011) Practical field Ecology: A Project guide, Wiley-Blackwell
5. IUCN RED DATA BOOK - https://portals.iucn.org/library/node/16746
6. http://biodiversity-informatics-training.org/bi-curriculum/
7. https://www.tdwg.org/standards/
8. https://methodsblog.com/2015/05/26/beta_diversity/

ADDITIONAL RESOURCES:

1. Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd. ISBN: 8120353137, 978-812035313
2. Sinclair, A.R.E., Fryxell, J.M. and Caughley,G. (2006). Wildlife Ecology, Conservation and Management. Wiley-Blackwell, Oxford, UK.
3. Singh, S.K. (2005). Text Book of Wildlife Management. IBDC, Lucknow.
4. Banerjee, K. (2002). Biodiversity Conservation in Managed and Protected Areas. Agrobios, India.
5. Sharma, B.D. (1999). Indian Wildlife Resources Ecology and Development. Daya Publishing House, Delhi.
6. www.indiabiodiversityportal.org
7. Magurran,A.E. 2013. Measuring Biological Diversity, John Wiley.
9. Primack, R.B. (1998). Essentials of Conservation Biology. Sinauer Associates, Inc. Sunderland, MA.
10. Rachel Carson (1962) A Silent Spring, Houghton Mifflin Company .

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DISCIPLINE SPECIFIC ELECTIVE COURSE - 10: Plant Tissue Culture

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Plant Tissue Culture **BOT-DSE-10**	4	**2**	**0**	2	Semester VI	**Nil**

COURSE LEARNING OBJECTIVES

To give students knowledge of techniques used in plant tissue culture and its applications.

LEARNING OUTCOMES

The successful students will be able to:

- Learn principles and processes in plant cell and tissue culture.
- Understand the use of tissue culture techniques in plant improvement, resource generation and conservation.
- Apply the concepts and principles of plant cell and tissue culture in biotechnological and agricultural fields.
- Become an entrepreneur by establishing their own plant tissue culture lab to have mass propagation of commercially important plants.

THEORY: 30 Hours

Unit 1 Introduction **(3 hours)**

Historical perspective, important contributions of Haberlandt, White, Reinert & Steward, Murashige, Skoog, Cocking, Guha & Maheshwari, Morrel & Martin. Terminologies: Cell and organ culture, explant, callus, totipotency, plasticity, regeneration, somaclonal variants.

Unit 2 Types and composition of Media and Techniques of Plant Tissue Culture **(8 hours)**

Role of nutrients, vitamins, hormones and supplements in nutrient medium. Composition of MS and White medium. Collection of plant material, sterilization of tissue (maintenance of aseptic conditions by use of autoclave and laminar flow chamber), filter sterilization, inoculation.

Unit 3: Micropropagation and Protoplast culture **(10 hours)**

Selection of plant material and suitable explant, methodology, plant regeneration pathways-somatic embryogenesis, organogenesis, difference between somatic and zygotic embryos. Protoplast isolation (mechanical and enzymatic), culture, purification (viability test) and fusion (spontaneous, induced), selection of fused protoplasts, applications.

Unit 4: Tissue culture applications **(9 hours)**

Anther culture, Production of haploids, triploids and cybrids, artificial seeds (production & advantages), embryo rescue, virus elimination, secondary metabolite production; Cryopreservation; Germplasm conservation. Novel sources of variation.

PRACTICALS **(60 hours)**

l. To study the equipment used in tissue culture: autoclave and laminar air flow chamber.
2. Preparation of Murashige & Skoog's (MS) medium.
3. Demonstration of sterilization and inoculation methods using leaf and nodal explants of tobacco, carrot, *Datura*, *Brassica* etc. (any two).
4. Study of anther, embryo and endosperm culture.
5. Study of micropropagation, somatic embryogenesis & artificial seeds.
6. Isolation of protoplasts.
7. Visit to a plant tissue culture laboratory and submission of field report.

SUGGESTED READINGS:

1. Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations {Elsevier}
2. Bhojwani, S.S, Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
3. Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text Springer
4. Bhojwani, S. S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice, Revised Edition, Elsevier
5. Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition Springer

ADDITIONAL RESOURCES:

1. Park, Sunghun (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition Elsevier
2. Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition CBS / Oxford & IBH
3. Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition {Elsevier}
4. Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 2nd Edition Wiley-Blackwell
5. Trigiano, R. N. (2011). Plant Tissue Culture, Development, and Biotechnology CRC Press

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 11: Reproductive Ecology

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CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reproductive Ecology **BOT-DSE -11**	4	**2**	**0**	**2**	Semester VI	Nil

COURSE LEARNING OBJECTIVES :

1. To acquaint students about the diversity in floral architecture, floral rewards so that they can correlate the concepts with breeding mechanisms.
2. To help them appreciate the adaptive significance of various traits associated with pollination, seed dispersal and seedling recruitment.
3. To sensitize students towards challenges faced by flowering plants on account of climate change and other anthropogenic activities.
4. To build on the concepts of inbreeding and outbreeding depression, seed ecology and resource allocation.

LEARNING OUTCOMES: After completing this course students will:

1. Become familiar with interesting concepts involved in understanding of reproductive ecology such as floral rewards, plant-pollinator interactions and pollinator guilds.
2. Have an understanding of intricacies and complexities involved in the reproductive success.
3. Will have background knowledge and an opportunity to utilize this knowledge to undertake interdisciplinary research.in conservation biology and other allied fields such as plant breeding.

THEORY: 30 Hours

Unit 1: **Introduction to Reproductive Ecology and Floral Biology** **(6 hours)**

Concept of reproductive ecology: Significance and scope. Floral architecture, floral phenology, sexuality, cryptic sexuality, reproductive allocation, evolution from solitary flowering to inflorescence, floral attractants, and rewards (pollen, nectar, scent, colour).

Unit 2: Pollination Ecology amd **Pollen-Pistil Interactions and Mating Strategies** **(6 hours)**

Pollination types, adaptations; plant-pollinator interactions (generalized and specialized pollination system, including mutualistic and non-mutualistic interactions), pollinator guilds; pollen banks. Factors affecting pollen-pistil interactions (abiotic, biotic, and anthropogenic); pollen flow. Sexual incompatibility (recognition and rejection reactions); inbreeding and outbreeding depression; resource allocation.

Unit 3: Seed Ecology **(4 hours)**

Seed development (sexual and apomictic), dispersal mechanisms (primary and secondary), dormancy, viability, germination; seedling recruitment; seed banks.

Unit 4 : **Challenges and Contemporary Issues in Reproductive Ecology** **(6 hours)**

Impact of climate change on sexual reproduction**,** global pollinator crisis and pollination failure; habitat fragmentation and altitudinal shifts; impact of invasive species on native plants and pollinators.

PRACTICAL **(60 hours)**

1. To study diversity in floral architecture (type of soil, temperature, humidity etc. to be mentioned).
2. To carry out histochemical tests in pollen (proteins, lipids, starch).
3. To study the structure of nectary of any flower available in the campus (through section, whole mount).
4. To analyse nectar volume and composition (using refractometer/chromatography)
5. To study through temporary preparations - types of stigma (dry and wet) and style (hollow and solid).
6. To study pollen-pistil interaction by demonstrating activity of (**ANY ONE)** esterase, acid phosphatase and peroxidases.

**Project work/Field Trip: Seed dispersal mechanism, Phenological calendar of flower, Estimation of Pollen Production in Anthers (with large number/ small number of pollen grains), or any other topic from the syllabus

SUGGESTED READINGS:

1. Tandon, R., Shivanna, K.R., Koul, M. (Eds) 2020. Reproductive Ecology of Flowering Plants: Patterns and Processes. Springer LINK
2. Shivanna, K.R., Tandon, R. 2014. Reproductive Ecology of Flowering Plants: A Manual. Springer LINK
3. Lovett-Doust, J., Lovett-Doust.L. 1988. Plant Reproductive Ecology: Patterns and Strategies: Oxford University Press, USA.
4. Rustagi, A., Chaudhry, B. (Eds) 2022. Plant Reproductive Ecology-Recent Advances. Intech Open, London, U.K
5. Mangla,Y., Khanduri, P., Gupta, C.K. 2022. Reproductive Biology of Angiosperms: Concepts and Laboratory Methods. Cambridge University Press.

ADDITIONAL READINGS

1. Spencer C.H. Barrett & Christopher G. Eckert (1990) Current issues in plant reproductive ecology. Israel Journal of Botany 39:1-2, 5-12.
2. Nicolson, S.W., Wright, G.A. 2017. Plant–pollinator interactions and threats to pollination: perspectives from the flower to the landscape. Functional ecology 31:22-25
3. Hicks, L. 2020. Flowers colors are changing in response to climate change; Pigment changes can make plants less attractive to pollinators. Science News

DISCIPLINE SPECIFIC ELECTIVE COURSE - 12: Intellectual Property Rights

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Intellectual Property Rights **BOT-DSE -12**	4	**2**	**0**	**2**	Semester VI	Nil

COURSE LEARNING OBJECTIVES

The objective of this course is to impart knowledge of rules, regulations, laws and processes of patents. Besides this students will have adequate knowledge of copyrights, trademarks and shall be thorough with the importance of traditional knowledge and protection of plant varieties.

LEARNING OUTCOMES:

After studying this course the students of Life Sciences will be well-equipped and well informed with the basics of IPR. Especially IPR in India. Students will be informed about the Patents that are integral to research. Students will have working Knowledge of various softwares and will be morally and ethically aware of the rights of the farmers, breeders and researchers.

THEORY : 30 Hours

Unit 1: Introduction to Intellectual Property Rights (IPR) and Geographical Indications and Industrial Designs (8 Hours)

Concept and types; economic importance, IPR in India and world, Genesis and scope, some important examples: IPR and WTO (TRIPS, WIPO), Objectives, Justification, International Position, Multilateral Treaties, National Level, Position of Govt. of India, Objectives, Rights, Assignments, Infringements, Defences of Design Infringement

Unit 2: Patents, Copyrights and Trademarks (9 Hours)

Introduction, Objectives, Rights, Patent Act 1970 and its amendments. Procedure of filing and getting Patents, Patent Infringement. Work protected under copyright law, Rights, Transfer of copyright, Copy right Infringement, Objectives of Trademarks, Types, Rights, Protection of Goodwill, Infringement, Passing off, Defenses, Domain name

Unit 3: Protection of Traditional Knowledge and Protection of Plant Varieties (7 Hours)

Objectives Concept of Traditional Knowledge, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, Need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO at National level, Traditional Knowledge Digital Library (TKDL).
Objectives of Plant Varieties Protection, Justification, International Position, Plant varieties Protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues related to farmers, breeders and researchers. National Gene Bank, Benefit sharing. Protection of Plant Varieties and Farmer's Rights Act, 2001.

Unit 4: Information Technology, Biotechnology and Intellectual Property Rights (6 Hours)

Computer Softwares and Intellectual Property, Database and Data Protection, Domain Name Protection, Patenting Biological/Biotechnological Inventions

PRACTICALS: 60 Hours

1. Patent search from different website.
2. Trademark search
3. Copyright infringement (Plagiarism check by Urkund and other available software.
4. Geographical Indicators: (Preparation of Inventories)
   Food- Malabar pepper, Basmati rice, Darjeeling Tea, and Requefort cheese.
   Industry- (Mysore agarbatti, Feni Goa, Champagne France).
   Natural Resources- Sandalwood
5. Biopiracy- Neem,Turmeric
6. Industrial designs- Jewelry design, chair design, car design,
7. To prepare IPR e diary.

SUGGESTED READINGS:

1. Misra J.P., 2023. An Introduction to Intellectual Property Rights 3rd Edition (Rep.) Central Law Publication
2. Karki MMS. 2009. Intellectual Property Rights: Basic Concepts. Atlantic Publishers & Distributors (P) Ltd ISBN13: 9788126912629
3. Redd,y S. V. Damodar. 2024. Intellectual Property Rights Law and Practice. Publisher: Asia Law House. ISBN: 9788119107483
4. Miller Arthur R., Davis Michael H. and Neacsu Dana. 2023. Intellectual Property, Patents, Trademarks, and Copyright in a Nutshell (Nutshells) 7th Edition. West Academic Publications. ISBN: 9781685619251
5. Bhandari MK. 2024. Law Relating to Intellectual Property Rights (IPR), Central Law Publication

ADDITIONAL READINGS

6. Mishra, J.P. 2012. An Introduction To Intellectual Property Rights. Central Law Publications. ISBN: 9789381292549, 938129254X
7. Acharya N.K. 2025. Text Book of Intellectual Property Rights. Asia Law House
8. Wadehra BL. 2017. Law Relating To Intellectual Property, Universal Law publishing company
9. Ramakrishna B, Anil Kumar H S. 2017. Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers. Notion Press

Bachelor of Life Science (Program)

SEMESTER VIII

UNIVERSITY OF DELHI

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VIII

Under UGCF-2022 based on NEP-2020

(Effective from Academic Year 2022-23)

Index

Department of Botany

Courses offered in B.Sc. Life Science Semester VIII with Botany as Major Discipline (course contents)

SEMESTER –VIII

(Under UGCF-2022 based on NEP-2020)

DISCIPLINE SPECIFIC CORE COURSE-8: Plant Stress Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	**Credits**	**Credit distribution of the course**			**Eligibility criteria**	**Pre-requisite of the course (if any)**
		Lecture	**Tutorial**	**Practical/ Practice**		
Integrative Plant Biology **LS-DSC-BOT-8**	4	**2**	**0**	**2**	Semester VII	Nil

COURSE LEARNING OBJECTIVES:

This course would involve study of plants to enhance the understanding of organism/s and/or traits from organismal to molecular levels integrating various core disciplines of plant biology including, but not restricted to, morphology, anatomy, development, taxonomy, inheritance, physiology, biochemistry, molecular and cell biology, genomics, proteomics and bioinformatics studies along with an evolutionary context. Additional areas would include interactions of plants with other organisms in an ecosystem, biotic and abiotic challenges and plant responses, transgenic studies (basic and applied) and an ecological or environmental perspective, wherever applicable.

LEARNING OUTCOMES:

The course would allow students to integrate various sub-disciplines that have been studied over the preceding seven semesters to develop a holistic understanding of plant systems transgressing various subject areas within plant biology. The course would include two main approaches/components:

(i) Integrated case studies on selected plants from algae to angiosperms including all aspects of their growth, development and applications as outlined above.

(ii) Selected trait- or process-based studies of plants to understand the biological, evolutionary and molecular determinants of the traits.

Both these approaches would involve **study of research and review articles** that discuss contemporary questions in plant biology by integrating multiple approaches towards understanding a plant system, **in addition to textbooks**.

The course design would allow students to study important **paradigms in plant sciences**, and train them in **experimental design, data interpretation and adoption of multi-disciplinary approaches to solve scientific questions**. The course would **enable development of critical thinking skills** among students and enhance their **problem-solving abilities**. This is an important component of the course since students in the 8th semester would be involved in B.Sc. Life Science with Botany as Major Discipline at the under-graduate level and would also be eligible to apply for Ph.D. programs in Botany.

THEORY: 30 Hours

Unit 1: Case studies and Trait-based studies on plants from algae to angiosperms (8 hours)

Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives Genome-editing: Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops. The renaissance and enlightenment of *Marchantia* as a model system, *Cuscuta* the Merchant of Proteins, The origin of a land flora. Important components of plant evolution – chloroplast acquisition, multicellularity and land colonization

Unit 2: Photosynthesis (8 Hours)

Lighting the way: Compelling open questions in photosynthesis research. Perspectives on improving photosynthesis to increase crop yield. Air plant genomes shed light on photosynthesis innovation. Alternative electron pathways of photosynthesis power green algal CO_2 capture,

Unit 3: Plant Development and Plant Biotic Interactions (9 Hours)

Molecular mechanisms underlying leaf development, morphological diversification, and beyond, Genetic control of branching patterns in grass inflorescences, Anther development—The long road to making pollen-, Evolution and patterning of the ovule in seed plants. Soil minerals affect taxon-specific bacterial growth. Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives.

Unit 4: RNA biology in Plants and Genome-editing (5 Hours)

Beyond transcription: compelling open questions in plant RNA biology. Small RNA-mediated DNA methylation during plant reproduction. Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops.

PRACTICALS: (60 hours)

1. Observation of phototactic movement in *Chlamydomonas* cells under microscope
2. Observe and compare chloroplast structures in *Chlamydomonas, Spirogyra, Marchantia,* and a land plant.
3. Analyze how selection or mutations affect leaf perimeter, area, lobation (wild vs cultivars of same species) by using ImageJ software.

4. Infer the evolutionary relationships among a group of plants based on trait presence/absence and create a cladogram using any phylogenetic tree making software.
5. Compare net oxygen release in normal vs low-CO_2 environment [one ambient air, one with limited CO_2 (limewater or CO_2 absorbent), measure bubble release (or use digital CO_2 sensor if available)].
6. Studying hormones modulate resource acquisition in root and shoot by application of Auxin and Cytokinin.
7. Demonstrate how plants activate defenses when exposed to pathogens using Leaf disc Assay
8. Observation of change in Morphology, Biomass, Visual Symptoms or Trait effected in same species under different biotic or abiotic stress like: Drought, Pathogen challenge, Pollinator exclusion, Elevated CO_2 (placed under box having baking soda and vinegar which provide CO_2 burst) can be given as project.
9. Using online tool (CRISPRdirect) to set up a Virtual CRISPR Experiment.

SUGGESTED READING

1. Bowman., et al (2022). The renaissance and enlightenment of *Marchantia* as a model system. *The Plant Cell*, 34(10), pp.3512–3542. doi:https://doi.org/10.1093/plcell/koac219.
2. Paterlini, A., & Helariutta, Y. (2020). *Cuscuta* the Merchant of Proteins. Molecular Plant, 13(4), 533-535. https://doi.org/10.1016/j.molp.2020.01.007
3. Romanov, M. S., Bobrov, A. V. C., Iovlev, P. S., Roslov, M. S., Zdravchev, N. S., Sorokin, A. N., ... & Kandidov, M. V. (2024). *American Journal of Botany*, *111*(1), e16264. DOI: 10.1002/ajb2.16264
4. Bowman, J.L. (2022). The origin of a land flora. *Nature Plants*, 8(12), pp.1352–1369. doi:https://doi.org/10.1038/s41477-022-01283-y.
5. Lighting the way: Compelling open questions in photosynthesis research Eckardt et al. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 3914–3943, https://doi.org/10.1093/plcell/koae203
6. Perspectives on improving photosynthesis to increase crop yield Croce et al. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 3944–3973, https://doi.org/10.1093/plcell/koae132

ADDITIONAL REFERENCES

7. Air plant genomes shed light on photosynthesis innovation Andrew C Willoughby. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 3897–3898, https://doi.org/10.1093/plcell/koae213
8. Alternative electron pathways of photosynthesis power green algal CO_2 capture Gilles Peltier et al. *The Plant Cell*, Volume 36, Issue 10, October 2024, Pages 4132–4142, https://doi.org/10.1093/plcell/koae143
9. Beyond transcription: compelling open questions in plant RNA biology Manavella et al. *The Plant Cell*, Volume 35, Issue 6, June 2023, Pages 1626–1653, https://doi.org/10.1093/plcell/koac346
10. Small RNA-mediated DNA methylation during plant reproduction Hiu Tung Chow, Rebecca A Mosher. *The Plant Cell*, Volume 35, Issue 6, June 2023, Pages 1787–1800, https://doi.org/10.1093/plcell/koad010

11. Molecular mechanisms underlying leaf development, morphological diversification, and beyond Nakayama et al. *The Plant Cell*, Volume 34, Issue 7, July 2022, Pages 2534–254. https://doi.org/10.1093/plcell/koac118
12. Genetic control of branching patterns in grass inflorescences Elizabeth A Kellogg. *The Plant Cell*, Volume 34, Issue 7, July 2022, Pages 2518–2533, https://doi.org/10.1093/plcell/koac080
13. Anther development—The long road to making pollen- D Blaine Marchant, Virginia Walbot. *The Plant Cell*, Volume 34, Issue 12, December 2022, Pages 4677–4695, https://doi.org/10.1093/plcell/koac287
14. Evolution and patterning of the ovule in seed plants. Rudall, P. J. *Biological Reviews*, *96*(3), 2021, 943-960. doi: 10.1111/brv.12684
15. Soil minerals affect taxon-specific bacterial growth. Finley, B. K., Mau, R. L., Hayer, M., Stone, B. W., Morrissey, E. M., Koch, B. J., & Hungate, B. A. (2022). *The ISME journal*, *16*(5), 1318-1326.
16. Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives. Franklin, K. A., Sommers, P. N., Aslan, C. E., López, B. R., Bronstein, J. L., Bustamante, E., .. & Marazzi, B. *International Journal of Plant Sciences*, Volume *177, Issue* 3, 2016. Pages 217-234, https://www.journals.uchicago.edu/doi/pdf/10.1086/684261
17. Genome-editing: Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops. Trends in Biotechnology, Volume 42, Issue 5; P560-574 May 2024

Qamar U. Zaman

DISCIPLINE SPECIFIC ELECTIVE COURSE-13: PLANT STRESS BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Stress Biology **DSE-13**	4	**2**	**0**	**2**	Semester VII	Nil

COURSE LEARNING OBJECTIVES:

This course explores the physiological, biochemical, and molecular mechanisms by which plants respond to environmental stresses. It covers abiotic and biotic stress factors, their impact on plant growth and development, and adaptive mechanisms to mitigate stress effects. The course also introduces strategies for improving stress tolerance in crops.

LEARNING OUTCOMES:

At the end of this course students will be able to:

- Identify different types of plant stresses and their effects on plant physiology.
- Understand the molecular and biochemical responses of plants to stress.
- Analyze plant adaptation and tolerance mechanisms under stress conditions.
- Explore strategies to enhance plant resilience against environmental challenges.
- Apply knowledge of plant stress biology in agricultural and environmental contexts.

THEORY: 30 Hours

Unit 1: Introduction to Plant Stress Biology and Various abiotic stresses 10 hours

Types (abiotic and biotic), Perception, Acclimation vs Adaptation, Phenotypic plasticity, **Cross-**talk between abiotic and biotic stress responses.

- Drought stress- Physiological and Biochemical responses, Resistance or Tolerance mechanisms, Role of Aquaporins in drought tolerance.
- Salinity- Osmotic and Cytotoxic effects, Ion homeostasis, Salt-tolerant mechanisms: Developmental and Physiological protective mechanisms – exclusion vs tolerance, Osmoprotectants, Ion transporters, Compatible solutes- glycine betaine, proline
- Temperature - Cold and heat stress (in brief)

Unit 2: Biotic Stress 4 hours

Stress caused by Pathogens, Herbivores, Parasitic plants and Weeds, Susceptibility and Resistance, PR proteins, Pattern-triggered immunity and Effector triggered immunity. Role of plant-associated microbiomes (endophytes, rhizobacteria) in biotic stress resistance.

Unit 3: Stress Sensing and Signaling Mechanisms and Stress Tolerance 14 hours

Hormonal regulation (Abscisic acid, Jasmonic acid, Salicylic acid), Reactive Oxygen Species and Nitrous Oxide, Epigenetics, Salt Overly Sensitive pathway, Late embryogenesis abundant proteins (LEA), Calcium signaling, Calcium binding proteins.

Stress Tolerance Mechanisms: Antioxidant enzymes (Superoxide dismutase, Catalase, Peroxidase), Osmolytes, Secondary metabolites (Alkaloids, phenolics and terpenoids), Chaperones (Heat Shock Proteins), Cryoprotectants, Phytoalexins

Unit 4: Crop Improvement Strategies 2 hours

Traditional plant breeding (Mutation breeding, Protected cultivation) and Biotechnological approaches (brief account of stress tolerant genetically engineered plants).

PRACTICALS: 60 hours

1. To study the effect of salt stress on seed germination (percentage, plant shoot and root length).
2. To study the effect of stress (any one) on chlorophyll content.
3. To determine electrolyte leakage in stressed plants.

4. Estimation of total phenolic content using Folin-Ciocalteu regent.
5. To determine SOD or peroxidase enzyme activity in control and stress plants.

Experiments through demonstration (through photographs)

6. Study of plant adaptations under stress (Stomatal closure, Leaf curling, Root elongation, Stunted plant growth, Wilting) and Effect of ABA.
7. To demonstrate the effect of stress on total protein through 2-D gel electrophoresis profile.
8. Effect of stress on plant membranes.
9. Effect of biotic stress on plants through photographs (necrosis, rotting, nematode attack, apple scab, SAR).

SUGGESTED READINGS:

1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
2. Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.
3. Giri, B., & Sharma, M. P. (Eds.) (2021). Plant Stress Biology: Strategies and Trends. Springer Nature.

4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.) (2015). Biochemistry and molecular biology of plants. John wiley & sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE -14: Immunological Concepts and Applications in Plant Science

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Immunological Concepts and Applications in Plant Science DSE-14	4	**2**	**0**	**2**	Semester VII	Nil

COURSE LEARNING OBJECTIVES:

1. Understanding and Protecting Against Diseases

2. To understand how the immune system defends against viruses, bacteria, and other pathogens

3. To understand how our bodies fight off diseases

4. To Understand how the develop effective treatments and vaccines are developed and vaccines,

5. To learn how to manage conditions like autoimmune disorders.

6. To learn how organ transplantation is done

- **LEARNING OUTCOME:**

By understanding how the immune system works, we can develop public health initiatives and preventative measures to reduce the spread of infectious diseases. Immunology gives the knowledge of effective vaccines and treatments for infectious diseases. The student will understand why the immune system sometimes attacks the body's own tissues, leading to conditions like rheumatoid arthritis, lupus, and type 1 diabetes. Immunotherapy, which harnesses the immune system to fight cancer, is a rapidly growing area of research, and understanding immunology is crucial for developing and improving these treatments. The student would understand the foundation of vaccine development, allowing scientists to create safe and effective vaccines that protect against a wide range of diseases. The topic give the knowledge about how the immune system interacts with cancer cells is crucial for developing immunotherapies that can target and destroy cancerous tumors. Immunology study helps identify specific targets within the immune system that can be manipulated to treat a variety of diseases. Immunology is essential for determining tissue and organ compatibility during transplantation, helping to prevent the rejection of donated organs by the recipient's immune system. Immunology research plays a vital role in addressing global health challenges, such as fighting pandemics and developing vaccines for diseases that affect populations worldwide.

THEORY: **30 Hours**

Unit 1: Introduction to Immunological Concepts and Plant Immunity: 9 hours

Basic concepts of immunology, Innate and Acquired (Adaptive) immunity, Human Immune system, Concepts of antigen, epitope, hapten, valence, antibodies (immunoglobulins)- structure, types (IgG, IgM, IgA, IgD, and IgE) and functions, antigen-antibody reaction, antisera and vaccines. Immune system in plants, Comparison between the plant and animal immune system. Plant pathogens and pests, Plant-pathogen interactions; Compatible interactions (parasite virulence and host plant susceptibility), Incompatible interactions (parasite avirulence and host plant resistance), non-host and host -resistance, Horizontal and vertical resistance, coevolution of plant defence and pathogen attack mechanisms: the Zigzag Model. Role of Microbiomes in Plant Immunity (beneficial microbes enhancing defense).

Unit 2: Components of Plant Immunity: 10 hours

(i) **Innate Immunity/ Resistance**

Non-specific or Basal Resistance: Passive (Constitutive defenses) including pre-existing mechanical defences (cuticle, waxes, lignified cell wall, bark, trichomes, thorns); pre-existing biochemical defences (alkaloids, phenolic compounds, terpenoids, nutrient deprivation, phytoanticipins); **Active (Inducible Defences):** Pathogen-associated molecular patterns (PAMPs), pattern-recognition receptors (PRRs), PAMP-triggered Immunity (PTI). Popular Models of PTI in plants- Flagellin-induced Resistance,

Pathogen Race-specific resistance: Molecular Models of specific Host-pathogen Recognition, gene-for-gene or receptor-ligand model (Flor's Model), Pathogen effectors, Intracellular nucleotide-binding leucinerich repeat receptors (NLRs), Plant Resistance (R) genes, Avirulence (Avr) proteins/ Effectors, Effector-triggered susceptibility (ETS), Effector-triggered immunity (ETI), Hypersensitive response.

(ii) **Acquired Resistance**

Systemic Acquired Resistance (SAR), Induced Systemic Resistance (ISR) Priming of plant immunity for faster future responses.

Unit 3: Signal Transduction Pathways activated during Plant resistance: 5 hours

Phytohormone signaling: salicylic acid, jasmonic acid, ethylene; Calcium signaling: Calmodulin (CaM), Calcineurin B-like proteins (CBLs) in *Arabidopsis;* Mitogen-activated protein kinase (MAPK) Cascades; The Oxidative burst (ROS); Major transcription factor families in plant immunity (WRKY, NAC, MYB, bZIP)

Unit 4: Applications of immunology in Plant Science: 6 hours

Development of disease-resistant crops, engineering enhanced resistance in crops via gene editing (e.g., CRISPR-Cas9), developing novel biopesticides/ biocontrol agents based on induced systemic resistance (ISR), genetic engineering strategies for broad-spectrum resistance by Pseudo-Response Regulator (PRR) and chimeric PRR transgenes. RNAi based antiviral resistance (siRNA).

PRACTICALS: 60 hours

1. To study the structure of antibody (diagrammatic and crystal structure) digitally.
2. Study of diseased plants and identification of its causal pathogen based on visually observed symptoms (Viral, bacterial, Fungal - one disease each)
3. Analysis and interpretation of digitally represented zig-zag model
4. Analysis and Interpretation of Western blots
5. Understanding the concept of immunoprecipitation by performing immunodiffusion.
7. Study and applications of immunological techniques: ELISA, Immunodiffusion, Radioimmunoassay.

SUGGESTED READINGS:

1. Dhia Bouktila and Yosra Habachi (2021) *An Introduction to Plant Immunity*: Bentham Science Publishers, Sharjah, UAE.
2. Iakovidis, M., Chung, E. H., Saile, S. C., Sauberzweig, E., & El Kasmi, F. (2023). *The emerging frontier of plant immunity's core hubs. The FEBS journal, 290(13), 3311–3335. https://doi.org/10.1111/febs.16549*
3. Prescott, L.M., Harley J.P., Klein D. A. (2005). *Microbiology*, 6th edition: McGraw Hill, New Delhi.

ADDITIONAL READING:

Agrios, G.S. (2005) Plant Pathology 5th Edition: Elsewhere Academic Press, Amsterdam.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE -15: Advances in Genetics, Genomics and Plant Breeding

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advances in Genetics, Genomics and Plant Breeding DSE-15	4	**2**	**0**	**2**	Semester VII	Nil

COURSE LEARNING OBJECTIVES:

To give the knowledge on how to improve crop yields, disease resistance, and nutritional value, ultimately contributing to food security and sustainable agriculture.

To enable more precise and efficient plant breeding, leveraging genomic information to develop superior crop varieties.

LEARNING OUTCOME:

The student will learn the identification and selection of genes associated with desirable traits like higher yield, improved grain quality, and enhanced nutritional content. They will learn to to predict the breeding value of plants, accelerating the selection process and reducing the time required to develop new varieties. They will learn the gene editing techniques like CRISPR/Cas9 enable precise modifications of plant genomes to improve specific traits, further accelerating crop improvement. It alos give insights on the increased Disease Resistance and Stress Tolerance to develop varieties with enhanced immunity to pests and diseases, as well as resilience to environmental stresses like drought, salinity, and high temperatures. By developing crop varieties with higher yields, improved nutritional value, and resistance to pests and diseases, these advances contribute to increased food security and reduced reliance on chemical inputs. Climate-resilient crops developed through genomic-based breeding can help mitigate the effects of climate change on agriculture, ensuring food production. Genomics has revolutionized plant breeding by shifting from phenotype-based selection to genotype-based selection, enabling more precise and efficient trait selection. Continued advancements in genomics and plant breeding hold immense promise for developing crops with even greater resilience, nutritional value, and yield potential, further contributing to a more sustainable and secure food future. The application of artificial intelligence and machine learning in plant breeding: is also on the horizon, promising further advancements in speed, accuracy, and efficiency.

THEORY: 60 Hours

Unit 1: Chromatin Organization and Fine Structure of Gene and Current Trends in Genomics 04 Hours

Chromatin structure and packaging of DNA: architecture of chromosome in eukaryotes, karyotypes and ideogram. Fine structure of gene. Role of 3D genome architecture (chromosome looping, TADs) in gene regulation. Gene discovery and deciphering gene function for improvement of crops. Applications of genomics in agriculture, health and environment.

Unit 2: Crop Genetics, Molecular Cytogenetics and Applied Genetics 08 Hours

Genome analysis in crops; Utilization of aneuploids in gene localization. Evolutionary significance of chromosomal aberrations in crop improvement, molecular cytogenetical tools for identification and structural analysis of genomes, introgression studies and ploidy detection. Advances in Optical Mapping and Karyotype Evolution. Applications of molecular cytogenetics: Alien gene transfer studies, gene mapping of agronomic traits and crop improvement in wheat, rice, tomato and cotton. Application of transposons in mutagenesis, genome mapping and evolution. Genomic approaches to minor and orphan crops.

Unit 5: Epigenomics and Metagenomics and Genome Editing Techniques 08 Hours

Epigenomics: DNA methylation, histone modifications and chromatin remodelling; Epialleles: inheritance and role in genetic regulation. Basic tools for studying epigenomics: Overview of Bisulfite sequencing and ChIP-Seq. Applications in crop improvement and disease management. Introduction to metagenomics; Environmental metagenomics: role in pollution control and ecosystem management. Plant microbiomes and their roles in stress tolerance and nutrient uptake. Introduction to genome editing, CRISPR-Cas9; applications of genome editing in agriculture and medicine. Ethical concerns: Designer babies, GMOs, and genome editing regulations.

Unit 4: Genetic Systems, Breeding Methods and Molecular Breeding 10 Hours

Gene pools (primary, secondary and tertiary), systems of mating, breeding methods for sexually, asexually/clonally propagated crops; self-incompatibility, male sterility and apomixis. Heterosis: types, genetic and molecular basis; Inbreeding. Molecular DNA markers and mapping populations, construction of high-density maps, QTL mapping, Association mapping. Integration of genetic maps with physical maps/chromosomes. Gene tagging, Marker Assisted Selection (MAS), Bulk Segregation Analysis (BSA), Genomic selection and Genome Wide Association Studies (GWAS). Breeding for biotic and abiotic stresses, and quality traits. Variety development and release of new varieties, Plant breeders and Farmers' rights.

PRACTICALS: 60 hours

1. Preparation of karyotype and ideogram from mitotic metaphase spread and analysis of degree of asymmetry.
2. Study of molecular cytogenetics: identification of progenitor genomes in allopolyploids crops using GISH (wheat, rice, tomato and cotton).
3. Mapping of ribosomal DNA gene using FISH.
4. Localization of Gene introgression using Fiber-FISH/ND-FISH.
5. Pedigree construction and analysis based on inheritance of monogenic traits in humans.
6. Access a plant-specific genome database (e.g., *Oryza sativa* in Gramene or *Arabidopsis thaliana* in TAIR).
7. Search for transcription factors linked to abiotic stress (e.g., drought, salinity). Note down their family (e.g., MYB, WRKY), function, and expression pattern.
8. Study of DNA methylation in plants using methylation sensitive enzymes.
9. Exploration of Single Nucleotide Polymorphisms (SNPs) in plants and their role in trait variation using Bioinformatics databases and tools.
10. Demonstration of basic method of selfing, emasculation, hybridization and crossing techniques in field/potted plants.
11. Comparison of characteristic features of released and notified varieties, hybrid and parental lines.
12. Comparison of quality parameters in improved varieties of cereals, pulses and oilseeds.
13. Genetics/Genomics/Plant breeding in News/Societal issues: presentation on a news article. Articles should have been published within last 2 years.

SUGGESTED READING:

1. Phundhan Singh (2014). Plant Breeding: Molecular and New Approaches. Kalyani Publishers
2. Phundhan Singh (2015). Essentials of Plant Breeding. Kalyani Publishers
3. B.D. Singh (2022). Plant Breeding: Principles and Methods, 12th Edition. MedTech Science Press.
4. Arthur M. Lesk (2017), Introduction to Genomics, 3rd Edition, OUP Oxford

- Hartl, D.L. Jones, E.W (2009), Genetics: Analysis of Genes and Genomes, 7th Edition, Jones&BarlettPublishers
- Peter S Harper (2010). Practical Genetic Counselling, 7th Edition, CRC Press
- Genetics A Molecular Approach, Russell PJ, Pearson
- Introduction to Genetic Analysis, Griffith AF et al., W H Freeman & Co
- Concepts of Genetics, Klug WS&Cummings MR, Prentice-Hall, Genetics – a conceptual approach, Pierce BA, W H Freeman & Co
- Principles of Genetics, Sunstad DP & Simmons MJ, John Wiley & sons
- Genetics Analysis of Genes & Genomes, Hartl, D.L. Jones, E.W. Jones & Barlett
- Genetic Analysis, Phillip Meneely, Oxford
- The Eukaryotic Chromosome, Bostock CJ & Summer AT, Elsevier
- Structure & Function of Eukaryotic Chromosomes, Hennig W, Springer
- Genes IX, Lewin B, Pearson
- Genome 3, Brown TA, Garland Publishing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE -16: Plant Genomics, Proteomics and Bioinformatics

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Genomics, Proteomics and Bioinformatics DSE-16	4	**2**	**0**	**2**	Semester VII	Nil

LEARNING OBJECTIVES

- To give understanding of the entire genome, including DNA sequences, gene architecture, and functional annotations, providing a holistic view of plant biology It will give the advanced knowledge in areas like crop improvement, disease resistance, and climate change adaptation.
- To provide a comprehensive understanding of plant biology at the molecular level, enabling researchers to identify key genes, proteins, and pathways involved in various plant processes.
- This knowledge can be used to develop more resilient and productive crops through advanced breeding and genetic engineering techniques.

LEARNING OUTCOME:

Genomics helps identify genes related to important traits like yield, disease resistance, and nutritional content, enabling the breeding of superior crop varieties. By understanding how genes respond to environmental stress, genomics can be used to develop plants that are more resilient to drought, heat, and other climate-related challenges. Proteomics focuses on the study of proteins, their structures, and functions, providing insights into cellular processes and protein interactions. Proteomics can identify proteins involved in defense mechanisms against pathogens, helping to develop new strategies for disease management. Proteomics helps understand how proteins respond to environmental stress, providing valuable information for developing stress-tolerant crops. Bioinformatics provides the computational tools necessary to analyze the vast amount of data generated by genomics and proteomics. Bioinformatics tools are used to build and maintain databases that store and organize plant genomic and proteomic data. Bioinformatics can be used to predict gene function, protein structure, and protein-protein interactions, providing valuable insights into plant biology.

The combination of genomics, proteomics, and bioinformatics provides a powerful approach for understanding plant biology and developing new strategies for crop improvement and adaptation. By integrating data from different omics disciplines, researchers can gain a more comprehensive understanding of plant systems, including gene regulation, protein interactions, and metabolic pathways. The insights gained from genomics, proteomics, and bioinformatics can accelerate the breeding process, leading to faster development of improved crop varietie

THEORY: 30 Hours

Unit 1: Introduction to Genomics and Genome Sequencing
08 Hours

Recap of genomic concepts: genomes, genes, and non-coding regions, prokaryotic and eukaryotic genomes. Basic concepts of structural, functional, and comparative genomics. Introduction to genomics, metagenomics, functional genomics, and system biology. Model organisms in genomics (*A. thaliana*, *E. coli, C. elegans, S. cerevisiae*). Methods for whole genome sequencing (shotgun & clone by clone), next generation sequencing, Genome sequencing projects (Human genome project, *Arabidopsis* genome project, Rice genome project).

Unit 2: Transcriptomics and Proteomics 12 Hours

Transcriptome sequencing, gene expression studies by EST, microarray and RNA sequencing.

Protein Identification, quantification, characterization, structural and bioinformatics analysis. Conventional proteomics (Native and SDS-PAGE, 2D-PAGE, Western blotting, ELISA), chromatography (Paper, Thin Layer, Size exclusion, Gel filtration, Ion exchange, Affinity); Visual proteomics (X-ray crystallography, NMR); Gel-free, Marker free MS-analysis by nano LC-MS/MS, Data-Dependent Acquisition (DDA), targeted and global proteomics analysis including PTM analysis, localization studies and functional analysis using TargetP, KEGG and GO.

Applications: Basic biological research (protein interaction networks and functional proteomics); disease research and diagnosis (Cancer biomarkers and virus research); drug development; agriculture and food science (crop improvement) and environmental monitoring.

Unit 3: Bioinformatics and Biological databases 04 Hours

Historical background; aims and scope of bioinformatics in Genomics, Transcriptomics, Proteomics, Metabolomics. Introduction to biological databases; study of following databases: NCBI - Resources and tools (BLAST, BankIt, Sequin, Webin), EMBL, DDBJ databases; Nucleic acid databases (GenBank, NDB); Protein databases (PIR, Swiss-Prot, PDB); Metabolic pathway database (KEGG).

Unit 4: Basic concepts of Sequence alignment and Molecular Phylogeny (06 Hours)

Similarity, identity and homology. Concepts of alignment (gaps and penalty); Alignment – local and global alignment, pairwise and multiple sequence alignments.

Molecular Phylogeny, construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees- maximum parsimony, maximum likelihood and distance methods.

PRACTICALS: 60 Hours

1. Sequence retrieval (protein and gene) from NCBI (formats- FASTA, GenBank and GenPept formats).
2. Perform pairwise alignment using BLAST.
3. Multiple sequence alignment (MEGA/Clustal omega).
4. Gene annotation using ORF Finder & gene prediction using GENSCAN
5. Locate the genome databases of prokaryotic and eukaryotic organisms (2 each) with completely sequenced genomes and categorize them based on taxonomy and genome size.
6. Protein Structure retrieval from PDB (in PDB format) and visualization by viewing tools (RasMol/Jmol/Mol*/Swiss 3D Viewer/PyMol).
7. To Perform Native and SDS-PAGE for separation of proteins.
8. Demonstration of 2D-PAGE for separation of protein isoforms.
9. Characterization of proteins using Western blotting.
10. Purification of proteins using Gel filtration chromatography.
11. *In-silico* characterization/analysis of proteins using localization, PTMs and functional annotation tools (using TargetP, KEGG and GO).

SUGGESTED READING

- Xiong, J. (2006). Essential Bioinformatics, 1st edition. Cambridge University Press. U.K.
- Pevsner, J. (2009). Bioinformatics and Functional Genomics, 2nd edition, Wiley Blackwell. New Jersey, U.S.

- Mount, D.W. (2004). Bioinformatics: Sequence and Genome analysis 2nd edition, Cold Spring Harbor Laboratory Press, USA.
- Ghosh, Z., Mallick, B. (2008). Bioinformatics – Principles and Applications, 1st edition. Oxford University Press, New Delhi, Delhi.
- Baxevanis, A.D., Ouellette, B.F., John (2005). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd edition. Wiley & Sons, Inc. New Jersey, U.S.
- Roy, D. (2009). Bioinformatics, 1st edition. Narosa Publishing House, New Delhi, Delhi.
- Andreas, D., Baxevanis, B.F., Francis, Ouellette. (2004). Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition. John Wiley and Sons, New Jersey, U.S.
- Lesk A (2020). Introduction to Bioinformatics, 5th Edition, Oxford University Press. India.
- David mount (2004) Bioinformatics: Sequence and genome analysis, 2nd Edition, Cold Spring Harbor Lab Press.
- Baxevanis A.D., Ouellette, B.F. (2004) Bioinformatics: A practical guide to the analysis of genes and proteins, John Wiley & Sons Inc.
- Dov Stekel (2003) Microarray Bioinformatics, 1st Edition. Cambridge University Press.
- Arthur M. Lesk (2017), Introduction to Genomics, 3rd Edition, Oxford University Press.
- Pennington SR, Dunn MJ (Eds.) (2002). Proteomics: From Protein Sequence to Function, BIOS Scientific Publishers, United Kingdom.
- Daniel C Liebler (2006) Introduction to Proteomics-Tools for New Biology. Humana Press, Totowa, NJ.
- Twyman, R (2014) Principles of Proteomics. Second edition. Garland Science, Taylor and Francis group, UK.
- Comai, L; Katz J and Mallick, P (2017) Proteomics-Methods and Protocols, Springer Protocols, Springer New York.

Bachelor of Applied Life Sciences with Agrochemicals and Pest Management

SEMESTER VII

UNIVERSITY OF DELHI

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VII

Under UGCF-2022 based on NEP-2020

(Effective from Academic Year 2022-23

Department of Botany
Courses offered in B.Sc. Applied Life Science with Agrochemicals and Pest Management

SEMESTER –VII

(Under UGCF-2022 based on NEP-2020)

Index

*These courses are already approved.

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Plant Tissue Culture ALS-DSE 7	**4**	**2**	**0**	**2**	**VI Sem**	**Nil**

Course Learning Objectives

To give students knowledge of techniques used in plant tissue culture and its applications.

Learning Outcomes

The successful students will be able to:

- learn the basic concepts, principles and processes in plant cell and tissue culture.
- understand the use of tissue culture techniques in plant improvement.
- apply the concepts and principles of plant cell and tissue culture in biotechnological and agricultural fields.
- become an entrepreneur by establishing their own plant tissue culture lab.

Theory; 30 Hours

Unit 1 Introduction **08 Hours**

Historical perspective, Important contributions of Haberlandt, White, Reinert & Steward, Murashige, Skoog, Cocking, Guha & Maheshwari, Morrel & Martin. Terminologies: Cell culture,organ culture, explant, callus, totipotency, plasticity, regeneration, somaclonal variants. Role of nutrients, vitamins, hormones and supplements in nutrient medium. Composition of MS and White medium.

Unit 2 Techniques of Plant Tissue Culture **08 Hours**

Collection of plant material, sterilization of tissue (maintenance of aseptic conditions by use of autoclave and laminar flow chamber), filter sterilization, inoculation. Protoplast isolation (mechanical and enzymatic), culture, purification (viability test) and fusion (spontaneous, induced), selection of fused protoplasts, applications

Unit 3 Micropropagation **05 Hours**

Selection of plant material and suitable explant, methodology, plant regeneration pathways-somatic embryogenesis, organogenesis, difference between somatic and zygotic embryos.

Unit 4 Tissue culture applications **09 Hours**

Anther culture, Production of haploids, triploids and cybrids, artificial seeds (production & advantages), embryo rescue, virus elimination, secondary metabolite production; Cryopreservation; Germplasm conservation. Novel sources of variation.

Practicals **60 Hours**

- To study the equipment used in tissue culture: autoclave and laminar air flow chamber.
- Preparation of Murashige & Skoog's (MS) medium.
- Demonstration of sterilization and inoculation methods using leaf

and nodal explants of tobacco, carrot, *Datura*, *Brassica* etc. (any two).

- Study of anther, embryo and endosperm culture.
- Study of micropropagation, somatic embryogenesis & artificial seeds.
- Isolation of protoplasts.
- Visit to a plant tissue culture laboratory and submission of field report.

Suggested Readings:

- Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations {Elsevier}
- Bhojwani, S.S, Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
- Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text Springer
- Bhojwani, S. S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice, Revised Edition, Elsevier
- Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition Springer

Additional Resources:

- Park, Sunghun (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition Elsevier
- Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition CBS / Oxford & IBH
- Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition
- {Elsevier}
- Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 2nd Edition Wiley-Blackwell
- Trigiano, R. N. (2011). Plant Tissue Culture, Development, and Biotechnology CRC Press

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre- requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Applied Phycology ALS-DSE 5	4	2	0	2	VI Sem	Nil

Course Learning Objective:

To gain knowledge about diversity, life forms, life cycles, morphology and economic importance of algae.

Learning Outcomes:

On completion of the course the students will be able to understand:

- use of algae for environment, human welfare and industries.
- algal culture techniques and their commercial production

Theory : 30 Hours

Unit 1: Scope of phycology **09 hour**

In emerging research areas, environment and industries. Nutritional value of algae; Common edible algae; Algae as food, feed and fodder with suitable examples. Phycocolloids (Agar-agar, Alginic acid and Carrageenan) and secondary metabolites: Sources and Applications; Pharmaceutical and Nutraceutical uses of algae; Algae in cosmetics; Diatomaceous Earth.

Unit 2: Algae in agriculture and environment **09 hours**

Algae as soil conditioners and biofertilizers; Seaweed liquid extract; Seaweed powder; Algal biorefinery residues. Algae as pollution indicators; wasteland reclamation; Role of algae in wastewater treatment; Ecological importance of Symbiotic associations of algae; Harmful algal blooms; Red tides; Algal toxins.

Unit 3: Algae in biotechnology and research **08 Hours**

Gene sequencing and algal systematics; Algae as a model organism (Chlamydomonas, Chlorella, Acetabularia, Ectocarpus,Porphyra); Bioluminescent forms; Algae in nanotechnology. Biofuels (Bioethanol, Biodiesel, Biohydrogen); Algal Biorefinery.

Unit 4: Algal culture techniques and commercial production **04 Hours** Isolation, purification and sterilisation of algae; Freshwater and marine culture media (BG-11 and Provasoli ES medium); Photobioreactors and large-scale production of microalgae; Seaweed farming.

Practicals **60 hours**

1. Isolation and identification of algal species (any three) in water samples from polluted and non-polluted sources through temporary mounts.
2. Nutritional analysis (protein and carbohydrates) of *Spirulina/ Chlorella/* anyother available edible algae.
3. Study of algal symbiosis (*Azolla* fronds) through sectioning or tease mount.
4. Phycocolloid (Agar-agar/ Alginates/ Carrageenan) extraction (demonstration/ digital resources).
5. Microalgal culture - maintain cultures of species isolated in Experiment 1(any three).
6. Commercial applications of algae through photographs/products (edible, cosmetics, biofuels, pharmaceutical, nutraceutical, phyco-remediation).
7. Study of algae as a model organism (any 2) through digital resources.
8. Project work on any applied aspect of algae/ Visit to any Institute or Industry (Report to be submitted).

Suggested Readings:

1. Bold, H.C. and Wynne, M.J. (1985) Introduction to the Algae: Structure and Reproduction, 2nd edition. Prentice-Hall International INC.
2. Chapman, D.J. and Chapman, V.J. (1980) Seaweeds and their uses. 3rdedn. British Library.
3. Kumar, H.D. (1999) Introductory Phycology, 2nd edition. Affiliated East-West Press, New Delhi.
4. Lee, R.E. (2008) Phycology, 4th edition: Cambridge University Press, Cambridge.
5. Sahoo, D. (2000) Farming the Ocean*:* Seaweed Cultivation and Utilization. Aravali Book International, New Delhi.

Additional Resources:

1. Andersen, R.A. (2005) Algal Culturing Techniques. Elsevier Academic Press.
2. Chapman, D.J. and Chapman, V.J. (1973) The Algae. 2ndedn. Macmillan, London.
3. Fleurence, J. and Levine, I. (2016) Seaweed in Health and Disease Prevention. Academic Press publications.
4. Sahoo, D (2010). Common seaweeds of India. IK International Pvt Ltd.
5. Sahoo, D. and Seckbach, J. (2015) The Algae World. Vol 26 Cellular Origin, Life in Extreme Habitats and Astrobiology. Springer, Dordrecht.
6. Van den Hoek, C. Mann, D.G. and Jahans H.M. (1995) Algae: An Introduction to Phycology. Cambridge University Press.

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CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Industrial and Environmental Microbiology ALS-DSE 6	4	2	0	2	VI Sem	Nil

Course Learning Objectives:

- To introduce students to the concepts, principles, scope and applications of industrial and environmental microbiology.

Learning Outcomes:

Upon successful completion of the course, students will be able to:

- understand how microbiology is applied in manufacturing of industrial products
- know about design of bioreactors
- understand the rationale in medium formulation, design for microbial fermentation, sterilization of medium and air
- comprehend the techniques and the underlying principles in upstream and down-stream processing
- learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
- understand the basic principles of environment microbiology and application of the same in solving environmental problems - waste water treatment and bioremediation
- comprehend the various methods to determine the quality of water

Theory : 30 Hours

Unit 1: Microbes and quality of environment **04 Hours** Introduction and scope of microbes in industry and environment; Distribution and isolation of microorganisms from soil, air and water.

Unit 2: Bioreactors/Fermenters and fermentation processes **08 Hours** Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous Fermentations; Components of a typical bioreactor, Types of bioreactors:

laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Unit 3: Microbial production of industrial products 10 Hours

Microorganisms generally regarded as safe (GRAS); Downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization; Production of industrially important products: enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin)

Unit 4: Industrial and Environmental Applications 08 Hours

Applications of industrially important enzymes (protease, lipase, and penicillin acylase); Methods of immobilization and its advantages. Water pollution: various sources and control measures; Role of microbes in sewage and domestic wastewater treatment systems. Microorganisms as indicators of water quality: coliforms and faecal coliforms.

Practicals 60 Hours

1. Principles and functioning of instruments: autoclave, laminar air flow, incubators, types of fermenters.
2. Preparation of different culture media (Nutrient medium/ LuriaBertani medium/Potato dextrose medium/Czapek Dox medium).
3. Hydrolysis of casein andstarch by microorganisms.
4. Alcohol production by yeast using sugar/ jaggery.
5. Serial dilution method for isolation of microorganisms from water and soil and study of aero-microflora.
6. To determine the BOD of sewage water.
7. To qualitatively check the enzyme activity (phosphatase/amylase/cellulase) in soil samples.
8. To determine the microbial activity in soil by Triphenyltetrazolium chloride (TTC) assay or by measuring the CO_2 evolution.
9. Determination of coliforms in water samples using eosin methylene blue (EMB) medium.
10. Visit to any educational institute/ industry and a report to be submitted

Suggested Readings:

1. Bertrand, Jean-Claude, Caumette, P., Lebaron, P, Matheron, R., Normand, P., Sime• Ngando, T. (2015). Environmental Microbiology: Fundamentals and Applications. Amesterdam, Netherlands, Springer.
2. Joe, S., Sukesh (2010). Industrial Microbiology. S.Chand& Company Pvt. Ltd. New Delhi, Delhi.

3. Mohapatra.P.K. (2008). Textbook of Environmental Microbiology. I.K. International Publishing House Pvt.Ltd. New Delhi, Delhi.
4. Okafer, Nduka (2007). Modern Industrial Microbiology & Biotechnology. Science Pubishers, Enfield, NH, USA.
5. Pelzar, M.J. Jr., Chan E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. New Delhi, Delhi: McGraw Hill Education Pvt. Ltd., Delhi.

Additional Resources:

1. Alef K, and Nannipieri P (1995). Methods in Applied Soil Microbiology and Biochemistry, First Edition Academic Press, USA.
2. Atlas, Bartha. (1997). Microbial Ecology: Fundamentals and Applications. San Fransisco, SF. Pearson.
3. Casida, J.R. (2016). Industrial Microbiology. New Delhi, Delhi, New Age International Publishers.
4. Hurst C.J., Crowford R.L., Garland J.L. and Lipson D.A. (2007). Manual of Environmental Microbiology, American Society of Microbiology, USA.
5. Patel, A.H. (2008). Industrial Microbiology, Bangalore, India: McMillan India Limited.
6. Sharma, P.D.(2005). Environmental Microbiology. Meerut, UP: Alpha Science International, Ltd.
7. Stanbury, P.F., Whitaker, A., Hall, S.J. (2016). Principles of Fermentation Technology. Amesterdam, NDL:Elsevier Publication.
8. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology (9th edition). San Francisco, SF: Pearson Benjamin Cummings.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
Natural Resource Management **ALS-DSE 7**	4	2	0	2	**VI Sem**	**Nil**

Course Learning Objectives:

Natural Resources are materials from earth which support life and significantly meet the needs of people. The paper aims to describe the different types of natural resources and their management. Students will study about the importance of each natural resource and how and why they are threatened in current times. They will also be taught about sustainably using our resources

Learning outcomes: At the end of this course, students will be able to:

- understand the different resources available in nature
- learn the importance of each resource along with the threats to these resources
- gain an in-depth understanding of management of these resources and restoration of natural ecosystems
- study the importance of sustainable practices
- gain an insight into various initiatives taken the world over to save our natural resources.
- understand the concept of clean energy and management of waste

Theory 30 Hours

Unit 1: Natural Resources and Sustainable Utilization **05 Hours**

Definition, fundamental concepts and types, Concept, Goals, Approaches (economic, ecological, socio-cultural)

Unit 2: Land and Water Resources **10 Hours**

Forests (definition, threats, management); Agricultural practices and their impact; Soil degradation (causes, management and remediation/restoration strategies), Freshwater, Marine, Estuarine, Wetlands – Threats and Management

Unit 3: Biological Resources and Energy **05 Hours**

Biodiversity – Levels, Significance, Threats, Management, Clean energy strategies – Solar, Wind, Hydro, Tidal, Geo-thermal, Bio-energy

Unit 4: Climate Change, Contemporary practices and National and International Initiatives **10 Hours**

Impact, adaptation and mitigation (Land, Soil, Water, Biodiversity, Air), EIA, GIS, Energy Audits, Waste Management, Ecosystem Restoration, Carbon footprint, International Solar Alliance; Ramsar Convention; Basel Convention; Carbon Neutral Goals; Net- zero Coalition; Clean Development Mechanism; CAMPA (Compensatory Afforestation Fund Management and Planning Authority); Carbon Credits; REDD+ project, Renewable Energy Certificates

Practicals: 60 Hours

- Comparison of pH (pH meter) and salinity (Electrical Conductivity) of various soil samples.
- Comparison of field capacity of various soil samples.
- Comparison of pH (pH meter) and TDS (TDS meter) of various water samples.
- Comparison of salinity (titrimetric method) of various water samples.
- Calculation and comparison of BOD and COD of various water samples from given data.
- Comparison of species diversity in various communities by Shannon-Wiener Index.
- Measurement of dominance of woody species by DBH method in the college campus.
- Project (any one of the following):
    a. Rainwater harvesting (site visit)
    b. Ecological restoration (site visit)
    c. Energy audit
    d. Seed germination and seedling growth in garden and contaminated soils
    e. Composting
    f. Any other
- Field visit/s to any degraded ecosystem (landfill, polluted water body, invaded forest) or any ongoing restoration project site.

Suggestive readings:

- Vasudevan, N. (2006). Essentials of Environmental Science. New Delhi, India: Narosa Publishing House.
- Singh, J. S., Singh, S.P. and Gupta, S.R. (2006). Ecology, Environment and Resource
- Conservation. New Delhi, India: Anamaya Publications.
- Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. New Delhi, India: Prentice Hall of India Private Limited.

- Jordan III, W. R., Gilpin, M. E., Aber, J. D. (1987). Restoration Ecology: a synthetic approach to ecological research. Cambridge, Great Britain: Cambridge University Press.

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CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Intellectual Property Rights ALS-DSE 8	4	**2**	**0**	**2**	**VI Sem**	Nil

Course learning Objectives

The objective of this course is to impart knowledge of rules, regulations, laws and processes of patents. Besides this, students will have adequate knowledge of copyrights, trademarks and shall be thorough with the importance of traditional knowledge and protection of plant varieties.

Learning outcomes:

After studying this course, the students of Life Sciences will be well-equipped and well informed with the basics of IPR. Especially IPR in India. Students will be informed about the Patents that are integral to research. Students will have working Knowledge of various softwares and will be morally and ethically aware of the rights of the farmers, breeders and researchers.

Theory : 30 Hours

Unit 1: Introduction to Intellectual Property Rights (IPR) 03Hours

Concept and types; economic importance, IPR in India and world, Genesis and scope, some important examples: IPR and WTO (TRIPS, WIPO).

Unit 2: Patents, Copyrights and Trademarks 09 Hours

Objectives, Rights, Patent Act 1970 and its amendments. Procedure of filing and getting Patents, Patent Infringement, Introduction, Work protected under copyright law, Rights, Transfer of copyright, Copy right Infringement, Objectives, Types, Rights, Protection of Goodwill, Infringement, Passing off, Defenses, Domain name

Unit 3: Geographical Indications, Traditional Knowledge Protection and Industrial Design

09 Hours

Objectives, Justification, International Position, Multilateral Treaties, National Level, Position of Govt. of India, Objectives Concept of Traditional Knowledge, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, Need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO at National level, Traditional Knowledge Digital Library (TKDL), Objectives, Rights, Assignments, Infringements, Defenses of Design Infringement

Unit 4: Protection of Plant Varieties, IPR and Biotechnology

09 Hours

Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties Protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues related to farmers, breeders and researchers. National Gene Bank, Benefit sharing. Protection of Plant Varieties and Farmer's Rights Act, 2001, Computer Softwares and Intellectual Property, Database and Data Protection, Domain Name Protection, Patenting Biological/Biotechnological Inventions

Practicals: 60 Hours

1. Patent search from different website.
2. Trademark search
3. Copyright infringement (Plagiarism check by Urkund and other available software.
4. Geographical Indicators: (Preparation of Inventories)
   Food- Malabar pepper, Basmati rice, Darjeeling Tea, and Requefort cheese.
   Industry- (Mysore agarbatti, Feni Goa, Champagne France).
   Natural Resources- Sandalwood
5. Biopiracy- Neem,Turmeric
6. Industrial designs- Jewelry design, chair design, car design,
7. To prepare IPR e diary.

Suggested Readings:

- M.M.S. Karki (2009) Intellectual Property Rights: Basic Concepts. Atlantic Publishers & Distributors (P) Ltd. ISBN13: 9788126912629.
- Rajeev Babel (2023) Intellectual Property Rights in India | Bloomsbury Publications. Publisher Bloomsburry Publication.
- S.V. Damodar Reddy (2024) Intellectual Property Rights -- Law and Practice. Asia Law House. ISBN: 9788119107483.
- JP Misra (2023) An Introduction to Intellectual Property Rights 3rd Edition. Central Law Publication, India

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CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Prerequisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Stress Physiology: Concepts and Strategies **ALS-DSE 9**	**4**	**2**	**0**	**2**	**VI Sem**	**Nil**

Course Learning Objectives:

This course explores the physiological, biochemical, and molecular mechanisms by which plants respond to environmental stresses. It covers abiotic and biotic stress factors, their impact on plant growth and development, and adaptive mechanisms to mitigate stress effects. The course also introduces strategies for improving stress tolerance in crops.

Learning Outcomes:

At the end of this course students will be able to:

- Identify different types of plant stresses and their effects on plant physiology.
- Understand the molecular and biochemical responses of plants to stress.
- Analyze plant adaptation and tolerance mechanisms under stress conditions.
- Explore strategies to enhance plant resilience against environmental challenges.
- Apply knowledge of plant stress biology in agricultural and environmental contexts.

Theory : 30 Hours

Unit 1: Introduction to Plant Stress Physiology **02 Hours**

Types (abiotic and biotic), Perception, Acclimation vs Adaptation, Phenotypic plasticity.

Unit 2: Abiotic and Biotic Stress **12 Hours**

Drought stress- Physiological and Biochemical responses, Resistance or Tolerance mechanisms
Salinity- Osmotic and Cytotoxic effects, Ion homeostasis, Salt-tolerant mechanisms: Developmental and Physiological protective mechanisms – exclusion vs tolerance, Osmoprotectants, Ion transporters, Compatible solutes- glycine betaine, proline
Temperature - Cold and heat stress (in brief)
Stress caused by Pathogens, Herbivores, Parasitic plants and Weeds, Susceptibility and Resistance, PR proteins, Pattern-triggered immunity and Effector triggered immunity.

Unit 3: Stress Sensing, Signaling and Tolerance Mechanisms **14 Hours**

Hormonal regulation (Abscisic acid, Jasmonic acid, Salicylic acid), Reactive Oxygen Species and Nitrous Oxide, Salt Overly Sensitive pathway, Late embryogenesis abundant proteins (LEA), Antioxidant enzymes (Superoxide dismutase, Catalase, Peroxidase), Osmolytes, Secondary metabolites (Alkaloids, phenolics and terpenoids), Chaperones (Heat Shock Proteins), Cryoprotectants, Phytoalexins

Unit 4: Crop Improvement Strategies 0**2 Hours**

Traditional plant breeding (Mutation breeding, Protected cultivation) and Biotechnological approaches (brief account of stress tolerant genetically engineered plants).

Practicals: **60 hours**

- To study the effect of salt stress on seed germination (percentage, plant shoot and root length).
- To study the effect of stress (anyone) on chlorophyll content.
- To determine electrolyte leakage in stressed plants.
- To determine SOD or peroxidase enzyme activity in control and stress plants.
- Study of plant adaptations under stress (Stomatal closure, Leaf curling, Root elongation, Stunted plant growth, Wilting) (through photographs).
- To demonstrate the effect of stress on total protein through 2-D gel electrophoresis profile (through photographs).
- Effect of stress on plant membranes (photographs).
- Effect of biotic stress on plants through photographs (necrosis, rotting, nematode attack, apple scab, SAR) (through photographs).

Suggested Readings:

- Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
- Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.
- Giri, B., & Sharma, M. P. (Eds.) (2021). Plant Stress Biology: Strategies and Trends. Springer Nature.

- Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.) (2015). Biochemistry and molecular biology of plants. John wiley & sons.

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Bachelor of Applied Life Sciences with

Agrochemicals and Pest Management

SEMESTER VIII

UNIVERSITY OF DELHI

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VIII

Under UGCF-2022 based on NEP-2020 (Effective from Academic Year 2022-23)

Department of Botany

Courses offered in B.Sc. Applied Life Science with Agrochemicals and Pest Management

SEMESTER –VIII

(Under UGCF-2022 based on NEP-2020)

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*These courses are already approved.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credit s	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Agriculture Botany and Weed Management ALS-DSC 8	4	2	0	2	Sem VII	Nil

Course Learning Objectives

By the end of this course, students will be able to:

- Explain the role of plants in agricultural systems and the impact of plant characteristics on crop productivity and adaptation.
- Identify major weeds affecting crop production and understand their biological and ecological characteristics.
- Analyze interactions between crops and weeds and their effects on yield and quality.
- Evaluate weed management strategies, both conventional and modern.
- Apply botanical knowledge to solve practical problems in crop and weed management.

Learning Outcomes

Upon successful completion of the course, students will be able to:

- Describe plant structures and functions essential for crop growth and development.
- Explain physiological processes and their relevance to crop productivity.
- Critically assess various weed control methods, including herbicide classification and mode of action.
- Design integrated weed management plans suited to specific cropping systems and ecological conditions.

Theory : 30 Hours

Unit 1 Seed Physiology and Physiology of Growth and Yield 09 hours

Seed dormancy, types, factors causing dormancy, mechanism and methods for breaking seed dormancy, seed viability and seed vigour, Principal of growth analysis, source-sink relationship, factors affecting growth, dry matter partitioning and yield, crop simulations and modeling, use of controlled environment for plant growth and development studies.

Unit 2: Plant Hormone and Reproductive Physiology **10 Hours**

Role of hormones in plant growth and development, commercial applications of growth regulators, growth retardant and its usefulness, Photoperiodism, flowering response, photo perception, critical photoperiod, photo-induction, phytochrome and its role in flowering, vernalization, physiology of fruit ripening, and senescence.

Unit 3: Biology of Weeds and Weed Management Practices **04 Hours**

Ecology of weeds, competition, reproduction of weeds, Mechanical Practices, Cultural Practices, Biological control.

Unit 4: Weed Control Methods **07 Hours**

Herbicide classification, Selectivity of herbicides, absorption and translocation of herbicides, Mode of action of herbicides, Detoxification mechanisms of herbicides. Weed resistance to herbicides, weed control in wheat, rice and vegetable crops. Control of five obnoxious weeds.

Practical : 60 Hours

- To study opening and closing of stomata.
- To determine stomatal index of the given leaf.
- To study the effect of ethylene on shelf life of cut flowers.
- To study the effect of cytokinin on leaf senescence.
- To study effect of heavy metals on growth and development.
- To test the viability of weed seeds.
- To evaluate the allelopathic effects of weeds on germination of crop seeds.
- To evaluate effect of herbicides on seed germination and seedling growth of weeds.

Suggested Readings:

1. Taiz, L. & Zeiger, E. 2006 Plant Physiology (5th edition) Sinauer Associates, Inc. Sunderland,
2. M.A.W.G. Hopkins (2009) Introduction to plant physiology, John Wiley and Sons Inc USA.
3. Mandal, R.C. (2010) Weeds, weedicides and weed control: Principle and Practice Agro Botanical Publishers, Delhi
4. Das TK (2011) Weed Science: Basics and Applications JPublisher ai Brothers
5. F. M. Ashton and T. J. Monaco (2002) *Weed Science: Principles and Practices*. John Wiley and Sons. Inc.
6. V. S. Rao (2002) *Principles of Weed Science.* Oxford and IBH Publishers, New Delhi

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CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Biofertilizers ALS-DSE 10	4	2		2	7Th Sem	**Nil**

Course Learning Objectives:

The Learning Objectives of this course are as follows:

- To develop an understanding of biological systems used as fertilizers and build skills in handling microbial inoculants.
- To understand the optimum conditions for growth and multiplication of useful microbes such as *Rhizobium*, cyanobacteria, mycorrhizae, *Azotobacter* etc.
- To understand the role of microbes in mineral cycling and nutrition of plants.
- To gain expertise in various methods of decomposition of biodegradable waste, conversion into compost and apply this knowledge and skill in their daily life.

Learning outcomes

On successful completion of this course, a student will be able to:

- visualize and identify different types of microorganisms with a compound microscope.
- understand the classification of microorganisms according to their shape/ structure for morphological identification. Prepare and sterilize different types of culture media.
- isolate of microorganisms from the environmental samples and culture in aseptic conditions.

Theory : 30 Hours

Unit 1: Introduction **08 hours**

Introduction to microbial inoculants or biofertilizers, macro and micro nutrition of plants, chemical fertilizers versus biofertilizers; Role of seaweed liquid fertilizers, Methods and steps in mass multiplication of biofertilizers: stock culture, broth culture, growth medium, fermentation, blending with the carrier, packaging, and quality check, ISI standard specification for biofertilizers; scope of biofertilizers in India.

Unit 2: Microbial Inoculants and Role of Cyanobacteria **09 hours**

Study of important microbial inoculants: *Rhizobium*, *Azospirillum*, *Azotobacter*, Actinorhizae; Characteristics, isolation, identification, and crop response, Role of Cyanobacteria (blue-green algae) in rice cultivation; *Azolla* and *Anabaena azollae* association, nitrogen fixation, and factors affecting growth.

Unit 3: Mycorrhizal association **08 hours**

Types of mycorrhizal association, taxonomy, occurrence and distribution; Role of Arbuscular mycorrhizal fungi in phosphorus nutrition, growth and yield of crop plants; AMF – methods in isolation (wet sieving and decanting), identification (morphological and molecular methods). Methods of inoculum production (Pot culture and root culture).

Unit 4: Organic farming **05 hours**

Introduction to organic farming, recycling of biodegradable municipal (domestic), agricultural and industrial waste; green manuring, bio-composting, vermicomposting and their field application.

Practical: **(60 Hours)**

1. Study of *Rhizobium* from root nodules of leguminous plants by Gram staining method.
2. Observation of arbuscular mycorrhizal fungi from plant roots.
3. Isolation of arbuscular mycorrhizal spores from rhizosphere soil.
4. Isolation of *Anabaena* from *Azolla* leaf.
5. Study of Earthworm, *Azolla*, AMF: Arbuscules-vesicles through specimen / digital resources.
6. Study of Biocontrol methods and their application -Pheromone trap, *Trichoderma*, *Pseudomonas,* Neem etc. through digital resources.
7. Rapid test for pH, $NO3^{-}$, $SO4^{2-}$, Cl^{-} and organic matter of different composts.
8. Projects on any one of the following topics: *Rhizobium* technology, AMF technology, Organic farming, Bio composting, Vermicomposting, *Azolla* culture etc. (The design of the project should be such that it includes a continuous work ofat least 6 Hours and a dissertation submission).

Essential/recommended readings

- Kumaresan, V. (2005). Biotechnology. New Delhi, Delhi: Saras Publication.
- Sathe, T.V. (2004). Vermiculture and Organic Farming. New Delhi, Delhi: Daya publishers.
- Subha Rao, N.S. (2020). Soil Microbiology, 5th edn. New Delhi, Delhi: Oxford & IBH Publishers.
- Reeta Khosla (2017). Biofertilizers and Biocontrol Agents for Organic Farming, Kojo Press.

Suggestive readings

- *Azotobacter* - Isolation and characterization - https://youtu.be/1Z1VhgJ2h6U
- *Rhizobium* - Identification and characterization - https://youtu.be/jELlo-pMvc4.
- 3-Days Online Workshop On Arbuscular Mycorrhizal Fungi - Biodiversity, Taxonomy and Propagation 19-2 (2022-01-20 at 02_27 GMT-8) - https://youtu.be/LKzK4IuSRc4.
- Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming. Nadiad, Gujarat: Akta Prakashan.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Environmental Biotechnology and Management ALS-DSE 11	4	2	0	2	Sem VII	Nil

Course Learning Objectives:

The course aims to build awareness of:

- various global and regional environmental concerns due to natural causes and/or human activities.
- different types of pollution and their impacts on the environment.
- existing and emerging technologies that are important in the area of environmental biotechnology to fulfill Sustainable Development Goals.

Learning Outcomes:

After completion of course the student will be able to:

- demonstrate awareness about emerging concerns such as climate change, waste management; biodegradation of xenobiotic compounds; bioremediation, etc.
- relate applications of biotechnology for alleviating the environmental concerns
- appreciate the scientific, ethical and/or social issues
- understand the national and international legislations, policies and role of public participation in Environmental Protection

Theory : 30 Hours

Unit 1: Environment **5 hours**

Basic concepts and issues, global environmental problems - ozone layer depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management. Fate of pollutants in the environment, Bioconcentration, Biomagnification.

Unit 2: Microbiology of waste water treatment **7 hours**

Aerobic process - activated sludge, oxidation ponds, trickling filter. Anaerobic process - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy and sugar industries.

Unit 3: Xenobiotic compounds and their treatment **10 hours**

Organic (Bio degradation of petroleum products and pesticides) and inorganic (metals, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, Bioaccumulation and Biosorption of metals, Treatment of toxic compounds: Role of immobilized cells/enzymes, microbial remediation, Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. Bioindicators and Bioprospecting

Unit 4: Legislations and Policies for Environmental Protection **08 hours**

Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Kyoto Protocol- 1997. Environmental ethics, Water Pollution (Prevention and Control) Act-1974, Air Pollution (Prevention and Control) Act- 1981, National Environmental Policy - 2006, Central and State Pollution Control Boards: Constitution and power.

Practicals: **60 hours**

1. To determine the pH and total hardness of water samples collected from different places (polluted and non-polluted sites)
2. To determine the salinity of water samples (polluted and non-polluted sites)
3. To determine the dissolved oxygen of two water samples.
4. To determine the alkalinity of water samples.
5. To determine the pH and rapid field test of soil samples (Chloride, Nitrate, and Sulphate).
6. To study microbes suspended in air and water samples.
7. A visit to any educational institute/ industry to understand the uses of microbes in environmental management and a report to be submitted for the same.

Suggested Readings:

1. De, A. K. (2022). Environmental Chemistry, 10th Edition, New Delhi. New Age International Pvt. Limited
2. Dennis, A., Seal, K.J., Gaylarde, C.C. (2004). Introduction to Biodeterioration, Cambridge University Press
3. Ahmed, N., Qureshi, F.M., Khan, O.Y. (2006). Industrial and Environmental Biotechnology, Horizon Press
4. Rochelle, P.A. (2001). Environmental Molecular Biology, Horizon Press.
5. Jadhav, H.V., Bhosale, V.M. (2015). Environmental Protection and Laws, Himalaya publishing House Pvt Ltd.
6. Trivedi, P. C. (2006). Biodiversity Assessment and Conservation, Agrobios Publ.
7. Rana, S.V.S. (2015). Environmental Biotechnology, Rastogi Publications, India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Plant Health & Disease Diagnostics ALS-DSE 12	4	2	0	2	**Sem VII**	**Nil**

Course Learning Objectives:

- understand the challenges and importance of plant pathogen diagnosis
- understand methods for reducing/minimizing risk of the spread of pathogens and pests.
- understand principles and tools for early warning systems to protect plant health.

Learning Outcomes:

At the end of this course, students will be able to:

- diagnose the cause of a plant disease and identify the causal agent
- select appropriate methods and strategy for control and mitigate spread.

Theory : 30 Hours

Unit 1: Introduction to Plant Diseases and Diagnosis **10 Hours**

Definition; History of Plant Pathology, Concept and basic components of disease; Causes and classification of diseases; Disease cycle; Significance of plant diseases, Koch's Postulates; Plant disease symptoms and types (Necrosis, Hypertrophy and Hyperplasia, Hypoplasia); General symptoms of viral, bacterial and fungal plant diseases; Methods of plant disease diagnosis- Histochemical, Serological and PCR techniques.

Unit 2: Plant Disease Epidemiology **05 Hours**

Epidemics and factors affecting the development of epidemics; Epidemic assessment and Disease forecasting; Tools of epidemiology geographic information system (GIS), Global Positioning System (GPS), Geostatistics, Remote sensing.

Unit 3: Plant Diseases **11 hours**

Causal organism, symptoms, disease cycle and management of the plant disease caused by bacteria, virus and fungi: Tobacco Mosaic, Yellow Vein mosaic of Bhendi, Citrus Canker, Angular leaf spot of Cotton, White rust of crucifers, Late & early blight of potato, Rust of wheat, Smut of Cereals.

Unit 4: Management of Plant Diseases **04 Hours**

Concept of integrated disease management (IDM); strategies for IDM- regulatory, cultural, physical, chemical and biological.

Practicals: **60 hours**

1. Preparation of Fungal Medium (Potato Dextrose Agar | Czapek Dox), Study of Instruments (Laminar Air flow, Autoclave, Incubator) & sterilization techniques.
2. Isolation pathogen from an infected plant sample.
3. Symptoms of Citrus canker and Angular leaf spot of Cotton through specimens / photograph.
4. Powdery mildew of pea: Symptoms and study of asexual and sexual stage of causal organism (*Erysiphe polygoni*) with the help of temporary tease /section/permanent slides.
5. Symptoms of Tobacco Mosaic Virus and Yellow Vein Mosaic of Bhinde through specimens / photographs.
6. White Rust of Crucifers - Symptoms and study of asexual and sexual stages of *Albugo candida* from tease /section/permanent slides.
7. Late blight of potato. Symptoms
8. Early blight of potato - Symptoms and study of asexual stage of *Alternaria solani* through temporary tease mounts
9. Black stem rust of wheat: Symptoms on both wheat and barberry. Types of spores of *Puccinia gormenis tritici* wheat and barberry by temporary tease/section mount/permanent slides.
10. Symptoms of Loose and covered smuts of barley.

Suggested Readings:

1. Cooke, B.M., Jones, D.G., Kaye, B. (2007) The Epidemiology of Plant Diseases, 2nd ed. Springer.
2. Madden, L.V., Hughes, G. and Bosch, F van den (2017). The Study of Plant Disease Epidemics, APS Publications.
3. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and their Allies. (2nd Edition), Medtech Publishers, Delhi.
4. Sharma, P.D. (2014*).* Plant Pathology. Rastogi Publications, Meerut.
5. Singh R.S. (2018*).* Plant Diseases. 10th Edition Medtech, New De

Additional Resources:

1. Agrios G.N. (2005*).* Plant Pathology. 5th Edition, Elsevier.
2. Gupta, V.K. and Sharma, R.C. (2020) Integrated Disease Management and Plant Health, Scientific Publishers, India
3. Kapoor, A.S. and Banyal, D.K. (2012). Plant Disease Epidemiology and Management, AbeBooks.

Credit Distribution, Eligibility and Pre-Requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Protected Agriculture–Hydroponics and Organic Cultivation **ALS-DSE 13**	**4**	**2**	**0**	**2**	**Sem VII**	**None**

Course Learning Objectives

The Learning Objectives of this course are as follows:

- To provide knowledge and expertise of various aspects of hydroponics, aquaponics and organic cultivation to students.
- To make students economically self-reliant by growing and marketing organic herbs, vegetables, microgreens and fruits.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will develop a thorough understanding of the concepts of Hydroponics, Aquaponics and Organic farming.
- Students will be trained in establishing hydroponic facility.
- Students will learn the development of various organic products such as biopesticides, biofertilizers and bio-organic growth promoters.
- Students will understand various government policies in marketing of hydroponic and organic produce.
- Students will understand Good Agricultural Practices associated with protected agriculture.

Theory : 30 Hours

Unit 1: Introduction to Protected Agriculture **02 hours**

Types of Protected Agriculture (hydroponics, aquaponics and organic farming), definition, history, terminology, importance and advantages over traditional agriculture, limitations and challenges.

Unit 2: Plant Growth Requirements and Media formulations **05 hours**

Physical parameters - light (quality and quantity) artificial light, light balancers; pH, conductivity, salinity (Dissolved Oxygen-DO, Total Dissolved Solid - TDS) and temperature; Chemical parameters- mineral nutrient requirements, deficiencies, toxicities, growth regulators (auxins, gibberellins, cytokinins and abscisic acids); Growth media- types, properties, uses, nutrient formulae, preparation of solutions, solid Media and nutrient film.

Unit 3: Hydroponic growing systems and associated pest & diseases 12 hours

Basic concepts and designs (closed and open systems techniques Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket and other small-scale systems), systems layout. Strengths and weaknesses of various systems, site considerations, componentry, nutrient delivery, pumping Hydroponics associated pest - mites, thrips, whiteflies, leaf miners; Identification and management of diseases -bacterial, fungal and viral diseases; safety practices (Good Agricultural Practices (GAP) and Integrated Pest Management (IPM).

Unit 4: Organic farming and its management, Marketing & Policies 11 hours

Organic farming and associated management practices (nutritional requirements, pest, diseases, weeds); use of biofertilizers, biopesticides, bioherbicides, biocontrol agents (plant growth promoting rhizobacteria (PGPR), pheromone trapping, *Trichoderma*, *Pseudomonas,* neem oil, garlic etc.) in management
Marketing of the produce and government institutes and policies related to protected farming (hydroponics and organic farming).
Practical: 60 hours

- Study of various instruments used in hydroponics.
- Preparation of growth media for hydroponics.
- Estimation of NPK, DO, TDS, pH of growing media.
- Demonstration of different irrigation techniques in hydroponics.
- Demonstration of construction of a sustainable hydroponic unit.
- Perform rapid tests for estimation of NPK in different soil samples (samples from at least three different sites).
- Bulk density and porosity of soilless media e.g. coco-peat, perlite, vermiculite,expanded clay, rockwool (any two media).
- Demonstration of growing a leafy vegetable/fruity vegetable/ medicinal herb/aromatic plant in Hydroponics solution.
- Study of traditional organic inputs and formulation of biofertilizer.
- Preparation of biopesticides, plant health promoters like *Panchgavya, Beejamrut*
- etc.
- Field visit to organic farm/hydroponic farm and submission of visit report.

Essential/recommended reading:

- Schwarz, M. (1995). Soilless Culture Management. Advanced Series in Agricultural Sciences, vol. 24. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-79093-5_2.
- Hasan, M., Sabir, N., Singh, A.K., Singh, M.C., Patel, N., Khanna, M., Rai, T., Pragnya, P. (2018). Hydroponics Technology for Horticultural Crops, Tech.

- Bull.TB-ICN 188/2018. Publ. by I.A.R.I., New Delhi-110012 INDIA.
- Misra S., Misra S., Misra R.L. (2017). Soilless Crop production. Daya Publishing House, Astral International (P) Ltd., New Delhi.
- Palaniappan S. P., Annadurai K. (2018). Organic Farming: Theory & Practice.Scientific Publisher.
- Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (2019). Aquaponics Food Production Systems. Springer, Cham.

Suggestive readings:

1. Jones, J. B. (2014). Complete Guide for Growing Plants Hydroponically. CRCPress.
2. Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming.Akta Prakashan, Nadiad.

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CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credit s	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Intelligent Plant Systems ALS-DSC-14	4	2	0	2	VII Sem	Nil

Course Learning Objectives

- The course aims to lay the foundations on plant intelligence and develops understanding of the intelligent adaptively variable behavior of plants.

Learning outcomes

- The students will be learning the concepts of intelligence, distinction between development and intelligent behavior and morphological /adaptive strategies employed by plants to survive.

Theory : 30 Hours

Unit 1: Introduction **03 hours**

An Introduction to Plant Structure (Morphological and Anatomical details).

Unit 2: Plants Intelligence and Sensory Biology **06 hours**

Brief History and Introduction to Plant Intelligence and Memory, Cell to cell communication, Self-recognition, Recognition of Neighbors and Relatives.

Unit 3: Learning in Plants **08 hours**

Habituation learning; Learning by association (Rhizosphere and Mycorrhizae); Adaptive Intelligence (Hydrophytes, Xerophytes, Parasites, Carnivorous plants, Thermogenic plants); Response to water, heat, salt and cold stress; Mechanical and chemical defense against predators with special reference to secondary metabolites.

Unit 4: Intelligent Behavior of Plants **13 hours**

A Guided tour to Plant Movements (Tropic Movements, Movement towards gravity, light, tracking sun movements, prey driven movements, liberation movements); Intelligent response to minerals and light (Seed germination, root cap, response of shoot, leaf morphology and anatomy); Unique pollination and seed dispersal mechanisms; Osmosis; Short and long-distance transport of water and food.

Practicals: **60 hours**

1. Study the structure of plant cell using temporary mount.
2. Study of the cell as an osmotic system (Plasmolysis and De-plasmolysis).
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Extraction and qualitative analysis of alkaloids, flavonoids, tannins and phenols.
5. To study the phenomenon of seed germination (effect of light).
6. To study light sensitivity and etiolation vs. de-etiolation.
7. Morphology and orientation of chloroplasts in leaves growing in light and dark, plasmodesmata connections and plasma membrane receptors. (through photographs or other digital resources).
8. Estimation of total photosynthetic pigments.
9. Study of (a) Root cap (b) Trichomes: non-glandular and glandular (c) Leaf Morphology and Anatomy (d) pulvinus anatomy in *Mimosa pudica* (e) Specialized motor tissue at the base of monocot leaves.
10. (a) Study of morphological and anatomical adaptations of hydrophytes, xerophytes.
    (b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*), Epiphytes, Predation (Insectivorous plants).
11. Pollination types (selected) and associated seed dispersal mechanisms.

Suggested Readings:

1. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
2. Evert, RF., Eichhorn, S.E. (2012). Raven Biology of Plants, 8th edition, New York, NY: W.H. Freeman and Company.
3. Koller, D. (2011). The Restless Plant. Edited by Elizabeth Van Volkenburgh, Haward University Press, Cambridge, Massachusetts, and London, England.
4. Crang, R., Lyons-Sobaski, S., Wise, R. (2018) Plant Anatomy- A Concept based approach to the structure of seed plants, Springer Nature, Switzerland.

Additional Resources:

Trewavas A. (2017). The foundations of plant intelligence. Interface Focus 7: 20160098. http://dx.doi.org/10.1098/rsfs.2016.0098.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

ZOOLOGY-NEP-UGCF-4th YEAR

GE PAPERS

SEMESTER – VII

List of GE Papers

Course Title	Nature of the Course	Total Credits	Components			Page No.
			Lectures	Tutorial	Practical	
Principles of Developmental Biology	Zoo-GE-17	4	2	Nil	2	19
Biology of Animal Cells	Zoo-GE-18	4	2	Nil	2	22
Immunology: Understanding the body's defense mechanisms	Zoo-GE-19	4	2	Nil	2	25
Concepts of Human Metabolism	Zoo-GE-20	4	2	Nil	2	28

GENERIC ELECTIVE COURSE -17

Principles of Developmental Biology

Zoo-GE -17

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Principles of Developmental Biology **Zoo-GE-17**	04	02	Nil	02	XII Class	Nil	Zoology

Learning Objectives

The learning objectives of this course are to:

- Identify the basic principles of developmental biology
- Understand the mechanisms associated with the development of organ system of the human body
- Acquaint the students with the fascinating transformation of a single cell (fertilised egg) into a fully developed, complex organism.
- Explain the basic principles and concepts underlying morphogenesis.
- Be able to investigate the effects of environmental factors on embryonic development.

Learning Outcomes

By studying this course, students will be able to:

- Understand the process and significance of formation of haploid germ cells
- Interpret the events that lead to formation of a multicellular organism from a single fertilized egg, the zygote.
- Understand the general patterns and sequential developmental stages during embryogenesis; and understand how the developmental processes lead to establishment of the body plan of multicellular organisms.

- Gain knowledge of the general mechanisms involved in morphogenesis and to explain how different cells and tissues interact in a coordinated way to form various tissues and organs.
- Become aware of the effects of pollutants/chemicals on abnormal embryonic development.

SYLLABUS

THEORY (30 hrs)

UNIT- 1: Introduction and Historical perspectives 2 hrs

Definition and scope of developmental biology; Importance of embryology in medicine and biology.

UNIT- 2: Gametogenesis, Fertilization and Placentation 14 hrs

Spermatogenesis and oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal), Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula. Types of placenta (shape and structure), Functions of Placenta, Amniocentesis.

UNIT- 3: Gastrulation 8 hrs

Process of Gastrulation in frog and chick. Fate of the three germ layers: ectoderm, mesoderm, and endoderm.

UNIT- 4: Metamorphosis and Teratology 6 hrs

Metamorphosis of Amphibian larvae to Adult. Teratogenesis, Teratogenic agents and their effects on embryonic development.

PRACTICALS (60 hrs)

(Laboratory periods: 15 classes of 4 hours each)

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula (Neural plate, Neural fold and Neural tube stages), tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): primitive streak stage, head process stage, head fold stage, 4-somite stage, 13-somite stage, 16-somite stage, 37-somite stage
3. Types of placentas with the help of photomicrographs/ slides.

PROJECT WORK

Project report on *Drosophila* or any insect culture/Visit to Poultry Farm/IVF Centre.

Essential/recommended readings

1. Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell.
2. Gilbert, S. F. (2010). Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA
3. Balinsky, B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition. International Thompson Computer Press.
4. Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.

Suggested readings

1. Baweja, V. and Misra, M. (2021). E-book on Practical Manual of Developmental Biology.

2. Arora, R. and Grover, A. (2018). Developmental Biology: Principles and Concepts. 1st Edition, R. Chand & Company.

3. Carlson, B.M. (2007.) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE -18

Biology of Animal Cells

Zoo-GE -18

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Biology of Animal Cells **Zoo-GE-18**	04	02	Nil	02	XII class	Nil	Zoology

Learning Objectives

The learning objectives of this course are to:

- Explore the diversity of the cells ranging from unicellular to multicellular organisms
- Explore the different models of the plasma membrane and various modes of transport across them
- Understand the fundamental structure of cell and its various functions.
- Examine the structural details of the cell organelles in relation to their role in the organism.
- Investigate the process of cell division and its relevance in the continuation of the species
- Analyse the various practical techniques to study the cell and its function.

Learning Outcomes

By studying this course, students will be able to:

- Explain the fundamental and functional principles of different types of cells
- Describe the structure and various models of plasma membrane and its role in transport of materials across cells
- Analyze the organizational details of key cell organelles involved in diverse cellular processes.

- Appreciate the characteristics of cellular growth, division, survival and death to regulate these important processes.
- Comprehend the process of cell division and its role in cellular cycle.
- Gain insights into the defects in functioning and regulation of cell organelles leading to diseases.
- Apply practical skills to understand the different cell division methods.

SYLLABUS

THEORY (30 hrs)

Unit 1: Types of Cells and Plasma Membrane 7 hrs

Virus, Viroids, Mycoplasma, Prokaryotic and Eukaryotic cells. Different structures and models of plasma membrane, Transport across membranes: active and passive transport, facilitated transport; Cell-cell junctions: Tight junctions, adherens junctions, gap junctions.

Unit 2: Endo-membrane System 6 hrs

Structure and Functions: Endoplasmic Reticulum, Vesicular transport from ER to Golgi apparatus; Protein sorting and transport from Golgi apparatus; Golgi apparatus, Vesicular transport: Coated Vesicles; Lysosomes; Peroxisomes.

Unit 3: Mitochondria and Cytoskeleton 8 hrs

Endo-symbiotic hypothesis; Respiratory chain, Chemi-osmotic hypothesis. Microtubules, Microfilaments and Intermediate filaments.

Unit 4: Nucleus and Cell Division 9 hrs

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Transport of molecules across nuclear membrane, Chromatin: euchromatin, heterochromatin and packaging, nucleosome, nucleolus. Mitosis, meiosis and regulation of cell cycle.

PRACTICALS (60 hrs)
(Laboratory periods: 15 classes of 4 hours each)

1. Principles of Microscopy: Compound microscope: Phase contrast microscope; Electron microscope; Differential Interference Contrast (DIC) Microscope.
2. Principle and types of cell fixation and staining; Cell fractionation.
3. Study of prokaryotic cells by Gram staining and eukaryotic cells (cheek cells) by staining with hematoxylin/methylene blue.
4.Study the effect of hypotonic, isotonic, and hypertonic solutions on cell permeability.
5. Preparation of a temporary slide of squashed and stained onion root tip to study various stages of mitosis.

6. Study of various stages of meiosis through permanent slides.
7. Preparation of stained mount to show the presence of Barr body in human female WBCs /cheek cells.

Essential/recommended readings:

1. Cooper, G.M., Hausman, R.E. (2019). The Cell: A Molecular Approach. VIII Edition, ASM Press and Sinauer Associates.
2. Becker, Kleinsmith, and Hardin (2018). The World of the Cell, IX Edition, Benjamin Cummings Publishing, San Francisco.
3. Karp, G. (2015). Cell and Molecular Biology: Concepts and Experiments, VIII Edition, John Wiley & Sons Inc.

Suggested readings:

1. Renu Gupta, Seema Makhija and Ravi Toteja (2018). Cell Biology Practical Manual, Prestige Publishers, New Delhi

2. V. K Sharma (1991). Techniques in Microscopy and Cell Biology, Tata McGraw-Hill Publishing Company Limited, New Delhi.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE -19

Immunology: Understanding the body's defence Systems

Zoo-GE -19

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Immunology: Understanding the body's defence System **Zoo-GE-19**	04	02	Nil	02	XII Class	Nil	Zoology

Learning Objectives

The learning objectives of this course are to:

- Describe the general difference between the innate and the adaptive immune system.
- Broadly describe how the innate and the adaptive immune systems mature in the body, how they interact with each other, and how they function in protecting the host from infections.
- Impart an in-depth knowledge on how our immune system fights with infection and foreign substances that can harm our body.
- acquire knowledge of the immunogenicity of biomolecules.

Learning Outcomes

By studying this course, students will be able to:

- Have an in-depth understanding of the innate and the adaptive immune system.
- Gain experimental skills and techniques frequently used in research in immunology.
- Develop essential skills in experimental design, techniques and execution, which are relevant to immunology.

- Comprehend and analyze the different cellular and humoral components of the immune system.
- Appreciate the contribution of various components of immune system in health and disease including basis of vaccination, autoimmunity, immunodeficiency and hypersensitivity

SYLLABUS

THEORY (30 hrs)

UNIT- 1: Basics of Immunology 5 hrs

History and scope of immunology; Types of immunity: innate and adaptive, Humoral and cell-mediated immunity, Active and Passive immunity; Cells and organs of the immune system, overview of Haematopoiesis.

UNIT- 2: Antigens and Antibodies 7 hrs

Antigenicity, immunogenicity; Structure and types of antibodies; Antigen-antibody interactions (agglutination, precipitation); Monoclonal antibodies production and their therapeutic applications.

UNIT- 3: Immune Response and Mechanisms 5 hrs

Major Histocompatibility Complex (MHC I & II); Exogenous and endogenous antigen processing; overview of Cytokines and complement system.

UNIT- 4: Immunological Disorders and Applied Immunology 13 hrs

Hypersensitivity reactions (Gell and Coomb's classification); Autoimmunity and autoimmune diseases (e.g., rheumatoid arthritis, thyroiditis); Immunodeficiency (e.g., SCID, AIDS. Vaccines and immunization programs; Principles of immunodiagnostics (ELISA, RIA, Western blot); Basics of Immunotherapy; Transplantation

PRACTICALS (60 hrs)
(Laboratory periods: 15 classes of 4 hours each)

1. Study of lymphoid cells and organs in rat/mouse*.
2. Identification of different blood cells using Leishman's/Giemsa/Crystal violet stained blood smear.
3. Blood group determination by ABO kit.
4. Cell counting and viability test (trypan blue dye exclusion test) from splenocytes from rat/mouse/any other species.
5. To understand the antigen and antibody interactions by:

i) Ouchterlony's double immunodiffusion method to study immunoprecipitation and interpretation of patterns of identity, non-identity and partial identity.
ii) Demonstration of ELISA.
iii) FACS

PROJECT WORK

Project on any topic/ Project report on visit to any research institute/laboratory to study the immunological techniques.

Essential/Recommended Readings

1. Owen, Punt, Stranford, Patricia Jones, Judy Owen (2018). Kuby Immunology (8th ed.). New York, WH: Freeman, ISBN: 978-1319114670
2. Kenneth Murphy, Casey Weaver (2016), Janeway's Immunobiology (9th ed.). Garland Science, ISBN: 978-0815345053
3. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006) Immunology, VI; Edition, W.H. Freeman and Company.
4. Abul Abbas, Andrew Lichtman, Shiv Pillai (2017). Cellular and Molecular Immunology; Elsevier
5. David, M., Jonathan, B., David, R. B. and Ivan, R. (2006) Immunology, VII Edition, Mosby, Elsevier Publication.

Suggested Readings

1. Peter Parham (2020) The immune System .(5th ed.). Garland Science, ISBN: 978-1285776902
2. Ivan Roitt, Ivan Roitt, and R. M. Hay (2016) Immunology (9th Edition) Blackwell Science.
3. Singh, I. K. and Sharma, P. [Eds.] (2022) An Interplay of Cellular and Molecular Components of Immunology. Taylor & Francis group, CRC Press.
4. Singh, I. K. and Sharma, P. [Eds.] (2022) Essentials of Immunology, Laboratory Manual; Prestige Publishers.
5. Kaur, H., Toteja, R., and Makhija, S. (2021) Textbook of Immunology, I.K International Publishing House and Wiley India Ltd.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE-20

Concepts of Human Metabolism

Zoo-GE -20

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Concepts of Human Metabolism **Zoo-GE-20**	04	02	Nil	02	XII Class	Nil	Zoology

Learning Objectives

The learning objectives of this course are to:

- Understand the concepts of various metabolic pathways.
- Obtain knowledge of the tissue metabolism and its regulation.
- Become conversant with the idea of enzyme specificity in metabolic pathways
- Learn how the body adjusts to variations in the demand for energy.

Learning Outcomes

By studying this course, students will be able to:

- Comprehend the fundamental concepts of metabolism.
- Better appreciate the importance and functions of carbohydrates, lipids, proteins in human metabolism.
- Comprehend the concept and mechanism of enzyme action and its regulation.
- Appreciate the importance of high energy compounds, electron transport chain, synthesis of ATP under aerobic and anaerobic conditions.

SYLLABUS

THEORY (30 hrs)

UNIT- 1: Overview of Metabolism 4 hrs

Concept of metabolism: anabolism and catabolism, general introduction of metabolic pathways; Regulation of metabolism (enzymatic and hormonal), compartmentalization of metabolism, Overview of digestion and absorption of carbohydrates, lipids and proteins.

UNIT- 2: Metabolism of Biomolecules: 21 hrs

Carbohydrates: Glycolysis, Citric acid cycle, Gluconeogenesis, Hexose Monophosphate pathway, Glycogen metabolism. **Lipids**: Beta oxidation of fatty acids, Metabolism of Ketone bodies, Metabolism during starvation. **Proteins**: Concept of Ureotelism, Uricotelism and Ammonotelism, Transamination, Deamination, Nitrogen metabolism, Ketogenic and glucogenic amino acids.

UNIT- 3: Electron transport System 3 hrs

Biological Redox systems; Overview of mitochondrial respiratory chain: electron carriers.

UNIT- 4: ATP Synthesis 2 hrs

Sites of ATP production, ATP synthesis- Oxidative phosphorylation and Substrate-level phosphorylation; Chemiosmotic theory, Shuttle systems.

PRACTICALS (60 hrs)

(Laboratory periods: 15 classes of 4 hours each)

1. To qualitatively identify the functional groups of carbohydrates
2. Estimation of total protein in given solutions by Lowry's method.
3. Separation of amino acids and lipids by chromatography.
4. Study the action of salivary amylase under optimum conditions.
5. To study biological oxidation using goat liver.

Essential/recommended readings

1. Stryer, L., Berg, J., Tymoczko, J., Gatto, G. (2019). Biochemistry (9th ed.). New York, WH: Freeman.
2. Nelson, D.L., Cox, M.M. (2017). Lehninger: Principles of Biochemistry (7th ed.), New York, WH: Freeman Company.

Suggested Readings

1. Voet, D., Voet. J. G. (2013). Biochemistry (4th ed.), New Jersey, John Wiley & Sons Asia Pvt. Ltd.
2. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry. XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER – VIII

List of GE Papers

Course Title	Nature of the Course	Total Credits	Components			Page No.
			Lectures	Tutorial	Practical	
Neurobiology	Zoo-GE-21	4	2	Nil	2	44
Classical and Molecular Cytogenetics	Zoo- GE- 22	4	2	Nil	2	48
Concepts of Evolutionary Ecology	Zoo-GE-23	4	2	Nil	2	51

GENERIC ELECTIVE COURSE -21

Zoo-GE -21

Neurobiology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical / Practice			
Neurobiology **Zoo-GE-21**	04	02	Nil	02	XII Class	Nil	Zoology

Learning Objectives

The learning objectives of this course are to:

- Understand the fundamental structure and function of the nervous system.
- Explore key concepts in Neurobiology in relation to non-zoology disciplines.
- Analyze the relationship between neurobiology and other areas of study.
- Develop critical thinking skills in evaluating neurobiological principles.

Learning Outcomes

By studying this course, students will be able to:

- Comprehend the structure and function of the nervous system, including neurons, glial cells, and synaptic transmission.
- Apply knowledge of neurophysiology, including action potentials, membrane potentials, and sensory-motor systems.
- Analyze the relationship between basic principles of neurophysiology and higher brain functions such as learning, memory, and behaviour.
- Identify and discuss common neurological disorders and their underlying neurobiological mechanisms.
- Evaluate interdisciplinary applications of neurobiology in fields such as psychology, medicine, and technology.
- Develop critical thinking skills through discussions, assignments, and examinations, fostering an understanding of neurobiological principles applicable to non-zoology disciplines.

SYLLABUS

THEORY (30 hrs)

UNIT 1: Introduction to Neurobiology and Neurophysiology 6 hrs

Overview of the nervous system and its subdivisions; Structural and functional differences between Neurons and Neuroglial cells; Composition and role of CSF, Blood-Brain barrier. Excitability of Neurons; Ion channels and membrane potentials, Generation of Action potentials. Excitatory and Inhibitory post-synaptic potential.

UNIT 2: Neuronal Communication 10 hrs

Types of Synapses, Receptors, and Neurotransmitters. Information processing by the nervous system: Sensory receptors and their types; Responses to key sensory stimuli/ impulses: Light (Vision), Smell (Olfactory), Auditory (Hearing), Touch (Tactile) and Taste (Gustatory).

UNIT 3: Higher Brain Functions 4 hrs

Brain regions and their specialized functions: Learning and Memory, Emotions and Behaviour. Overview of some Neurological Disorders (Alzheimer's, Parkinson's, Schizophrenia, etc.).

UNIT 4: Applications of Neurobiology 10 hrs

Applications of Neurobiology in Psychology, and Medicine: Neural mechanisms in maintenance of Circadian rhythms and their relationship to sleep-wake cycles; Sleep-related disorders: insomnia, sleep apnea, and shift work disorder; Role of sleep in mood regulation, stress (anxiety and depression) management; Mental wellness: Role of lifestyle, mindfulness, and early intervention; Advances in neuroscientific research: Brain imaging tools (EEG, fMRI, PET) Brain-Computer Interfaces (BCIs).

PRACTICALS (60 hrs)
(Laboratory periods: 15 classes of 4 hours each)

1. Microscopic examination of neuron structure using prepared slides.
2. Identification of different types of neurons (e.g., motor neurons, sensory neurons) and glial cells (e.g., astrocytes, oligodendrocytes) under the microscope.
3. Study of Anatomy of the Mammalian Brain (from slaughterhouse) or by using brain models (Plastic or clay anatomical teaching models, graphics, videos, etc. can be used).
4. Histological study of neurons and myelin sheath (Nissl and Luxol Fast Blue staining.)
5. Analysis of neurological and psychiatric disorders (e.g., Alzheimer's, Parkinson's, Schizophrenia) through clinical case vignettes and brain imaging.

Project on any one of the following topics:

1. Reaction Time and Sensory Coordination
2. Sleep Diary and Memory Recall Analysis
3. Case Study on Ethical Implications of BCIs or Neuro-prosthetics
4. Role of Brain Science in Advancing Artificial Intelligence

Essential/recommended readings:

- Mark F. Bear, Barry W. Connors, and Michael A. Paradiso (2015). Neuroscience: Exploring the Brain. IV Edition.
- Kandel, E.R., Schwartz, J.H. and Jessell, T.M. (2000). Principles of Neural Science. IV Edition, McGraw-Hill Companies.
- Kandel, E.R., Schwartz, J.H. and Jessell, T.M. (1995). Essentials of Neural Science and Behavior. I Edition, New York: McGraw-Hill

Suggested readings:

- Squire, L., Berg, D., Bloom, F. E., du-Lac, S., Ghosh, A., Spitzer, N. C. (2012). Fundamental Neuroscience, IV Edition, Academic Press Publications.
- Purves, D. et al., (2017) Neuroscience, VI Edition. Oxford University Press.
- Neuroethics: Defining the issues in THEORY, practice, and policy (2nd edn). Edited by Judy Illes
- Brain-Computer Interfaces: Principles and Practice (2012). Editors: Jonathan R. Wolpaw, Elizabeth Winter Wolpaw. Oxford University Press

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE -22

Classical and Molecular Cytogenetics

Zoo-GE -22

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Classical and Molecular Cytogenetics **Zoo-GE-22**	04	02	Nil	02	XII Class	Nil	Zoology

Learning Objectives

The learning objectives of this course are to:

- Understand the structure of chromosomes and its classification along with the condensation of DNA into chromosomes.
- Explore the transmission of the chromosomes from a generation to the next.
- Explain the organization and complexity of the human genome at the cytogenetic level.
- Investigate the nature of chromosomal abnormalities and related cytogenetic disorders.
- Evaluate appropriately the family pedigree and population and ethnic aspects of inherited disorders.
- Estimate the risk of recurrence of various inherited disorders in affected families.
- Acquire knowledge of the molecular cytogenetic tools which aid in prenatal diagnosis.

Learning Outcomes

By studying this course, students will be able to:

- Describe the condensation process of chromosomes along with their structural details.
- Have an in-depth understanding of chromosome transmission.
- Comprehend and analyze the factors leading to cytological disorders.
- Appreciate the role of genetic counselling in the prenatal stage.
- Develop essential skills for handling of cytogenetic tools such as FISH, PCR, and NSG used in genetic diagnostics.

SYLLABUS

THEORY **(30 hrs)**

UNIT- 1: Introduction to Cytogenetics **3 hrs**

Overview of cytogenetics and its historical development. Relationship between genetics, cytogenetics, and cytogenomics.

UNIT 2: Genomes and chromosomes **8 hrs**

Cell division: Mitosis, Meiosis, and the Cell Cycle. Sex chromosomes and their determination. Chromosome morphology and structure. Chromosomal aberrations and associated genetic diseases. Epigenetic mechanisms. Genomic analysis techniques.

UNIT- 3: Molecular Markers and Techniques in Cytogenetics **14 hrs**

Principles and applications of cytogenetic tools*: Karyotyping, FISH, CGH, DNA microarray, PCR, NGS, and CRISPR-Cas9. Basics of probe design and labelling. Emerging trends in the field. Microsatellites, Single nucleotide polymorphisms (SNPs), DNA sequencing techniques

UNIT- 4: Clinical Cytogenetics **5 hrs**

Genome instability and its role in cancers. Genetic counselling and Prenatal diagnosis.

PRACTICALS **(60 hrs)**
(Laboratory periods: 15 classes of 4 hours each)

1. Demonstration of cell culture techniques.
2. Study of Mitosis and Meiosis using permanent slides and squash techniques.
3. Chromosome staining methods: G-banding
3. Karyotype preparation and analysis of metaphase chromosomes for genetic disorders/abnormalities.
4. To study the methods, principles, and procedures of FISH
5. Demonstration of DNA microarray
6. To study applications of Next-generation sequencing (NGS) in cytogenetics
7. To perform Polymerase chain reaction (PCR) and Primer designing.

Essential/recommended readings

1. Textbook 1. Marilyn S. Arsham and Margaret J. Barch (2017) The AGT Cytogenetics Laboratory Manual, 4nd Edition.
2. J. McGowan-Jordan and A. Simons (2016) An International System for Human Cytogenomic Nomenclature Reprint of: Cytogenetic and Genome Research, Vol. 149, No. 1-2.
3. Rooney D.E., Czepulkowski B.H. (2001) Human Cytogeneitcs: A Practical Approach. Volume I og II, Oxford University Press.

4. Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.

Suggested readings

1. Susan Mahler Zneimer (2014) Cytogenetic Abnormalities: Chromosomal, FISH, and Microarray Based Clinical Reporting and Interpretation of Result
2. Steven L. Gersen and Martha B. Keagle (2004) The Principles of Clinical Cytogenetics

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE-23

Concepts of Evolutionary Ecology

Zoo-GE -23

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Concepts of Evolutionary Ecology **Zoo-GE-23**	04	02	Nil	02	XII Class	Nil	Zoology

Learning Objectives

The learning objectives of this course are to:

- Explore the interface of ecological and evolutionary forces that lead to the diversity of the form.
- Understand the function, and behaviour among animals.
- Impart an understanding of the evolutionary origin and drivers of biological variation and diversity, including the significance of genetic variation, natural selection, and genetic drift.
- Unravel the evolution of animals, sexual selection, evolution of mating systems, animal interactions, reaction norms and plasticity.

Learning Outcomes

- By studying this course, students will be able to :
- Better understand the diverse relationships that the organisms have in the environment.
- Analyze the patterns of distribution of animals in different regions and ecosystems.
- Gain insight into the major events in history of life
- Know the fundamental concepts of natural selection, speciation, mass extinction and macro-evolution.
- Explain the characteristics, dynamics, and growth of populations.
- Appreciate the characteristics of the community, ecosystem development and climax theories.

- Gain knowledge about the relationship of evolution of various species and the environment they live in.

SYLLABUS

THEORY (30 hrs)

UNIT- 1: Overview of Evolutionary Ecology **5 hrs**

Introduction to the relationship between evolution and ecology, Origin of life: chemogeny and endosymbiotic theory. Natural selection, adaptation and fitness. Ecological adaptations of animals to their environment.

UNIT- 2: **Population Ecology** **7 hrs**

Density, mortality, natality, dispersal and dispersion, life tables, fecundity tables, survivorship curves, age and sex ratios. Population growth- exponential and logistic. Life history traits - r and K selection. Population regulation, positive and negative interactions.

UNIT- 3: Community Interactions **6 hrs**

Community Characteristics: species richness, dominance, diversity and abundance. Organisation of community– habitat, niche, guilds, and dominant species. Interspecific interactions with examples. Species diversity indices. Categories of ecological succession. Climax community, Concept of keystone, flagship, umbrella species with examples.

UNIT- 4: Evolutionary Progressions, Concept of Species and Coevolution **12 hrs**

Natural selection and its types, Genetic drift, Artificial selection. Species concept, Isolating mechanisms, Modes of speciation (Allopatric, Sympatric, Parapatric and Peripatric), Adaptive radiation/macroevolution (Darwin's finches). Forms of coevolution (pairwise coevolution, diffuse coevolution, and gene-for-gene coevolution); Co-evolutionary interactions (Coevolution of competitors, Predator-prey coevolution, Host-parasite coevolution, Coevolution of mutualists); Evolutionary equilibria. Co-speciation and diversification.

PRACTICALS (60 hrs)

(Laboratory periods: 15 classes of 4 hours each)

1. Study of an aquatic ecosystem- phytoplankton and zooplankton: Sample collection of specimens from an ecosystem (pond/river/lake/forest/garden) to study its biotic components.
2. Estimation of turbidity/penetration of light, temperature, Dissolved Oxygen content (Winkler's method), determination of pH.
3. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community.

4. Plotting of different types of survivorship curves from the provided life tables of the hypothetical/real data.
5. Understanding the homology, analogy and homoplasy from suitable specimens.
6. Construction of cladograms based on morphological characters.
7. Study and verification of Hardy-Weinberg Law by Chi-square analysis

PROJECT WORK

Project report based on the visit to the natural history museum/National Park/Biodiversity Park/Wildlife Sanctuary.

Essential/recommended readings

1. Futuyma, Douglas and Mark, Kirkpatrick (2017) 3rd Ed. Evolutionary Biology, Oxford University Press
2. Hall, B.K. and Hallgrimson, B. (2013) Evolution; 5th Edition, Jones and Barlett Publishers.
3. Zimmer C. and Emlen D. J., (2013) 1st Ed. Evolution: Making Sense of Life, Roberts & Co.
4. Chapman, J., and Reiss, M. (2012). Ecology Principles and Applications; Cambridge University Press.
5. Odum, E. P. and Barrette, G. W. (2008) Fundamentals of Ecology; 5th Indian edition; Brooks/Cole
6. Miller, T., and Spoolman, S. (2008) 12th Edition Environmental Science- Problems, Concepts and Solutions; Thomson Brooks/Cole.

Suggested readings

1. Smith T. M. and Smith R. L. (2015). Elements of Ecology. 9th International Edition. Publisher: Benjamin Cummings.
2. Ridley, M. (2004). Evolution. III Edition, Blackwell publishing.
3. Southwood, T. R. E., & Henderson, P. a. (2000). Ecological Methods, 3rd Edition; Blackwell Science Ltd. (Vol. 278, Issue 5705).

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Annexure-4.10.08
EC dated 12.07.2025

Based on Undergraduate Curriculum Framework-2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER –VII AND SEMESTER –VIII B.Sc (P) Life Sciences

(4th Year of UG as per UGCF-2022 existing)

SEMESTER – VII

List of DSC Papers

Course Title	Nature of the Course	Total Credits	Components			Page No.
			Lectures	Tutorial	Practical	
Animal Models and Experimentation	DSC- 19	4	2	Nil	2	5

List of DSE Papers

Course Title	Nature of the Course	Total Credits	Components			Page No.
			Lectures	Tutorial	Practical	
Advanced Bio-techniques and Bioinstrumentation*	DSE- 18	4	3	Nil	1	10
Ichthyology	DSE- 19	4	3	Nil	1	13
Applied Entomology	DSE- 20	4	3	Nil	1	16

*Mandatory DSE to be offered in Semester-VII

SEMESTER – VIII

List of DSC Papers

Course Title	Nature of the Course	Total Credits	Components			Page No.
			Lectures	Tutorial	Practical	
Comparative Physiology of Vertebrates	DSC- 20	4	2	Nil	2	32

List of DSE Papers

Course Title	Nature of the Course	Total Credits	Components			Page No.
			Lectures	Tutorial	Practical	
Evolutionary Immunobiology of Animals*	DSE- 21	4	3	Nil	1	35
Faunal Conservation and Restoration	DSE- 22	4	3	Nil	1	38
Reproductive Endocrinology	DSE- 23	4	3	Nil	1	41

*Mandatory DSE to be offered in Semester-VIII

SEMESTER –VII

SEMESTER	DISCIPLINE SPECIFIC CORE COURSE (DSC)	DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)
VII	ZOO-DSC-19: Animal Models and Experimentation	Zoo -DSE-18: Advanced Biotechniques and Bioinstrumentation*
		Zoo-DSE-19: Ichthyology
		Zoo-DSE-20: Applied Entomology

*Mandatory DSE to be offered in Semester-VII

DISCIPLINE SPECIFIC CORE COURSE -19

Animal Models and Experimentation

Zoo-DSC-19

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical /Practice		
Animal Models and Experimentation **Zoo-DSC-19**	04	02	Nil	02	Should have appeared in Semester VI	-

Learning Objectives

The learning objectives of this course are as follows:

- To acquire an in-depth knowledge of the importance and applications of animal models in scientific research.
- To understand theoretical concepts, ethical principles and legal frameworks governing animal experimentation to assist in comprehending the quick response to pandemics in the form of vaccines.
- To gain theoretical and practical knowledge of experimental techniques using animal models.
- To develop skills to design experiments involving animal models for studies related to diseases, drug testing, and toxicity assessments/ Biomedical research.
- To explore alternatives to animal experimentation and their role in modern research.

Learning Outcomes

By studying this course, students will be able to:

- Have a better understanding of the concepts of the selection criteria, types, and applications of animal models in research.
- Demonstrate competence in handling, restraining, and administering treatments to animals in a humane and ethical manner.
- Analyze and interpret data generated from animal experiments.
- Critically evaluate the ethical considerations in using animals for research and propose alternatives when feasible.

- Design small-scale experiments using appropriate animal models to investigate scientific hypotheses.

SYLLABUS OF DSC-19

THEORY (30 hrs)

UNIT 1: Introduction to Animal Models 6 hrs

Definition and Importance, Historical perspective and significance in biomedical research. Types of Animal Models: Inbred, outbred, transgenic, and knockout models. Criteria for Selecting an Animal Model: Relevance to human biology. Ethical considerations.

UNIT 2: Experimental Design and Techniques 10 hrs

Design of Experiments (DoE): Importance of hypothesis-driven research. Sample size estimation and randomization. Tissue collection and processing. Gene Editing in Animal Models: CRISPR-Cas9 and its applications. Creating knockout and knock-in models.

UNIT 3: Application of Animal Models 8 hrs

Disease Models: Oncology - Induced tumour models. Neurological disorders: Alzheimer's and Parkinson's models. Metabolic disorders: Diabetes and obesity models. Infectious diseases: Models for tuberculosis, malaria, and viral infections. Drug Discovery and Toxicology: Role of animal models in preclinical trials. Acute and chronic toxicity studies. Use of animals in stem cell research.

UNIT 4: Ethical and Regulatory Aspects of Animal Experimentation 6 hrs

Ethics in Animal Experimentation: Importance of humane treatment of animals. Principles of the 3Rs: Replacement, Reduction, and Refinement. Regulatory Frameworks: CPCSEA (India) and International Guidelines. Role of Institutional Animal Ethics Committees (IAECs). Good Laboratory Practices (GLP) for animal studies. Alternatives to Animal Testing: *In-vitro* models, organoids, and computational models. Advantages and limitations of alternatives.

PRACTICALS (60 hrs)

(Laboratory periods: 15 classes of 4 hours each)

1. Selection and Handling of Animal Models: Basic handling and restraint techniques. for mice, rats, and zebrafish. Observation of behavior and physiological parameters.
2. Techniques in Experimental Research: Induction of disease models, Behavioral testing: Maze and anxiety tests. Sample collection: Blood and tissue collection techniques.
3. Histology and Imaging: Preparation of tissues for histological studies. Basic imaging techniques (e.g., fluorescent microscopy).
4. Ethical Simulations: Case studies on ethical dilemmas. Mock IAEC proposal writing and review.
5. Presentation of Findings - Preparation of Scientific Posters - Oral Presentation Skills for sharing Research Outcomes

6. Project on any topic/ Project report on visit to any research institute/laboratory to for understanding some ongoing research studies using any animal model.

Essential/Recommended readings

1. Guide for the Care and Use of Laboratory Animals – National Research Council 8th Edition, 2011 9 Publisher: National Academies Press; ISBN: 978-0-309-15400-0.
2. Laboratory Animal Medicine 2nd Edition, 2002 Publisher: Academic Press; ISBN: 978-0-12-263951-7– James G. Fox, Bennett J. Cohen, Franklin M. Loew.
3. Principles of Laboratory Animal Science, Revised Edition, 2001, Publisher: Elsevier ISBN: 978-0-444-50612-2– L.F.M. van Zutphen, V. Baumans, A.C. Beynen.
4. Handbook of Laboratory Animal Management and Welfare, 4th Edition, 2013, Publisher: Wiley-Blackwell; ISBN: 978-0-470-65567-1– Sarah Wolfensohn, Maggie Lloyd.
5. Ethics of Animal Research: Exploring the Controversy, 2012, Publisher: MIT Press; ISBN: 978-0-262-01734-6– Jeremy R. Garrett.

Suggested Readings

1. Experimental Design and Data Analysis for Biologists 2002, Publisher: Cambridge University Press; ISBN: 978-0-521-00976-8– Gerry P. Quinn, Michael J. Keough.
2. Animal Models in Biomedical Research, 2010, Publisher: Humana Press; ISBN: 978-1-60761-670-2 – Timothy G. Geary, Aaron Maule (Editors).
3. Alternatives to Animal Testing: New Ways in the Biomedical Sciences, 2008, Publisher: Wiley-VCH; ISBN: 978-3-527-32090-2 – Christoph A. Reinhardt. Laboratory Manual for Animal Research, 1997, Publisher: Oxford University Press; ISBN: 978-0-19-511908-4– Tom L. Beauchamp *(A practical resource for students learning techniques in animal research and experimentation).*
4. CPCSEA Guidelines for Laboratory Animal Facility, 2003 – Committee for the Purpose of Control and Supervision of Experiments on Animals (India).
5. Zebrafish: Methods and Protocols. 2012, Publisher: Humana Press; ISBN: 978-1-61779-597-8 – Allan V. Kalueff, Adam C. Gould.
6. Behavioral Research and Animal Welfare, 2019 Publisher: Springer; ISBN: 978-3-030-13966-1 – Edward Narayan.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -18
Advanced Biotechniques and Bioinstrumentation
Zoo-DSE-18

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Advanced Bio-techniques and Bioinstrumentation **Zoo-DSE-18**	04	03	Nil	01	Should have appeared in Semester VI	-

Learning Objectives

The learning objectives of this course are as follows:

- To understand advanced techniques used for research, diagnostics, and industrial applications Biotechnology.
- To learn the principles, applications, and limitations of bioinstrumentation methods.
- To gain hands-on experience in the operation and maintenance of advanced instruments.
- To develop critical thinking to select and apply suitable techniques for solving specific biological problems.
- To learn to interpret experimental data and troubleshoot issues in instrumentation.

Learning Outcomes

By studying this course, students will be able to

- Have a better understanding of the diverse cellular processes and cellular interactions.
- To explain the principles and working mechanisms of advanced instruments in biotechnology.
- To demonstrate proficiency in operating instruments like spectrophotometers, chromatographs, and PCR machines.
- To design experiments using advanced techniques like chromatography, electrophoresis, and mass spectrophotometry.
- To analyze experimental data generated by advanced bioinstrumentation.
- To apply biotechnological tools to solve problems in diagnostics, genomics, proteomics, and drug discovery.

Syllabus of DSE-18

THEORY (45 hrs)

UNIT- 1: Spectroscopic Techniques 10 hrs

Principles and Applications: UV-Visible spectroscopy, Fluorescence spectroscopy, Circular Dichroism (CD). Advanced Techniques: Infrared (IR) spectroscopy, Atomic Absorption Spectroscopy (AAS), and Nuclear Magnetic Resonance (NMR).

Applications: Structure determination, protein folding studies, and biomolecular interactions.

UNIT-2: Chromatography and Electrophoresis 10 hrs

Chromatography: Principles and applications of HPLC, Gas Chromatography (GC), and Ion Exchange Chromatography.

Electrophoresis: Polyacrylamide Gel Electrophoresis (PAGE), Agarose Gel Electrophoresis, 2D Gel Electrophoresis. Applications in genomics and proteomics.

UNIT-3: Molecular Biology Techniques 9 hrs

Polymerase Chain Reaction (PCR): qPCR, RT-PCR, and digital PCR.

DNA Sequencing: Sanger sequencing and Next-Generation Sequencing (NGS).

UNIT 4: Imaging and Analytical Tools 16 hrs

Microscopy: Principles and applications of Confocal Microscopy, Electron Microscopy (SEM, TEM). Mass Spectrometry (MS): Principles, instrumentation, and applications in proteomics and metabolomics. Biosensors: Principles, components, and applications of Biosensors in diagnostics.

PRACTICALS (30 hrs)

(Laboratory periods: 15 classes of 2 hours each)

1. Chromatography Techniques: Separation of biomolecules using Chromatography.
2. Electrophoresis Techniques: SDS-PAGE for protein separation.
3. Amplification of DNA. Gel documentation and analysis of PCR products.
4. Imaging Techniques: Demonstration of SEM/TEM.
5. Biosensors: Demonstration of glucose biosensors and ELISA techniques.
   Project related to topics covered in Theory/ project report based on visit to labs/institutions/industry, etc.

Essential/recommended readings

1. 1. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker, 7th Edition (2010), Cambridge University Press.

2. Biophysical Chemistry: Principles and Techniques by Upadhyay, Upadhyay, and Nath, Revised Edition (2020), Himalaya Publishing.

3. Introduction to Spectroscopy by Donald L. Pavia et al., 5th Edition (2015), Cengage Learning.

4. Bioinstrumentation by John G. Webster, 1st Edition (2004), Wiley-Interscience.

Suggested readings

1. Fundamentals of Analytical Chemistry by Douglas A. Skoog et al., 9th Edition (2013), Cengage Learning.

2. Molecular Biology of the Gene by James D. Watson et al., 7th Edition (2013), Pearson.

3. Chromatography: Principles and Instrumentation by B.K. Sharma, Revised Edition (2007), Goel Publishing House.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -19
Ichthyology
Zoo-DSE-19

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Ichthyology **Zoo-DSE-19**	4	3	Nil	1	Should have appeared in Semester VI	-

Learning Objectives

The Learning Objectives of this course are as follows:
• To increase student familiarity with evolutionary history and taxonomic diversity of fishes.
• To improve understanding of the basic physiological and behavioural adaptations of fishes.
• To enhance students' skills in studying locally available fish species.
• To expose students to some of the issues surrounding the conservation of fish biodiversity in the environment.

The Learning Outcomes

After studying this course, students can:

- keep track of types of fishes and their morphology.
- get detailed knowledge about the physiology of fishes.
- attain knowledge of various feeding habits, adaptations, parental care, and reproduction of fishes.
- attain advanced knowledge about the fishes which would be helpful for designing experiments for research.

Syllabus- DSE-19:

THEORY **(45 hrs)**

Unit-1 Introduction to Fishes **16 hrs**
Introduction and types of fishes, Classification, General Characters, Fish Origin: The diversification and relationships of jawless and jawed fishes. Scales, Teeth, Muscles, Swim-bladder, Gills, Fins, Skull, Weberian ossicles, Lateral-line system.

Unit-2 Fish Physiology **15 hrs**

Gas exchange, Internal transport and Homeostasis- Aquatic and Aerial respiration, Cardiovascular physiology, Hematology, Lymphoid organs, osmoionic regulation, Acid-base balance, nitrogen excretion and metabolism, Sensory systems–photoreception, chemoreception, mechanoreception, electroreception.

Unit-3 Reproduction and Development 8 hrs

Oviparity and ovoviviparity, Prolific breeders, Fecundity, Induced breeding, Fish larval stages, Parental care in fishes.

Unit-4 Food and Feeding habits of Fishes and their Adaptations 6 hrs

Fish foods and feeding habits, Adaptations in hill stream and deep-sea fishes, Types of migration in fishes, Abiotic factors and their influence on fish.

PRACTICALS: (30 hrs)

(Laboratory periods: 15 classes of 2 hours each)

1. Identification of local fishes by physical key methods.
2. Study of different types of fish scales.
3. Study of chromatophores of fishes under microscope.
4. Analysis of water quality parameters viz. temperature, pH, dissolved oxygen.
5. Fish Morphometric measurements: Standard length, Total length, Fork length, Dorsal fin height, Pectoral fin length, Ventral fin length, Anal fin height.
6. Study of anatomy of digestive systems among different types of fishes.
7. Gonado-somatic index.
8. Study of Weberian ossicles and otoliths.
9. Visit to local fish market/farm and report preparation.

Essential/Recommended Readings:

- Biology of Fishes, Bone, Q. and Moore, R., Taylor and Francis Group, CRC Press, U.K.
- The Physiology of Fishes, Evans, D. H. and Claiborne, J. D., Taylor and Francis Group, CRC Press, UK
- The Senses of Fish Adaptations for the Reception of Natural Stimuli, von der Emde, R., Mogdans, J. and Kapoor, B. G., Narosa Publishing House, New Delhi, INDIA
- Ichthyology, Lagler, K.F., Bardach, J.E. and Miller, R.R. John Wiley and Sons Inc., New York, USA
- A textbook of fish biology and fisheries, Khanna S.S. and Singh H.R. Narendra publishing house, Delhi

Suggested readings:

- Ichthyology, Karl F. Lagler, John E. Bardach, Robert R. Miller, Dora R. May Passino, Wiley, New York, USA
- Ichthyology Handbook, Kapoor, B. G., Khanna, B. Springer Science & Business Media, 2004

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -20
Applied Entomology
Zoo-DSE-20

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisites of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Applied Entomology **Zoo-DSE-20**	04	03	Nil	01	Should have appeared in Semester VI	

Learning Objectives:

The learning objectives of this course are as follows:

- To impart in-depth knowledge about various aspects of the insect world.
- To gain theoretical and practical knowledge of experimental techniques using insects as research models.
- To understand the immense role of insects as ecosystem providers.
- To gain theoretical and practical knowledge of insects as pests and their economic impact.
- To explore pest management measures which are effective, economical and eco-friendly.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Learn about the fascinating world of insects from a holistic perspective.
- Learn about the biology of insects.
- Understand the difference between various types of beneficial and destructive insects.
- Gain knowledge about important insect pests of crops, fruits, vegetables, stored grains, and of medical importance.
- Analyze the advantages and limitations of the various pest management measures and then design/ customize more effective measures by targeting the lacunae in the existing methods of pest management and by integrating the various aspects of Integrated Pest Management (IPM).

SYLLABUS OF DSE-20

THEORY (45 hrs)

Unit 1: Exploring the Fascinating World of Insects. 10 hrs

Overview of the economic importance of insects: Beneficial insects (Honey bees, Silkworm, Lac insect, ecosystem service providers: flesh flies, dung beetles, termites); Insect pests of agricultural crops, stored grains, medical and household; Insects as forensic agents: role of insects/arthropods in criminal investigation by predicting time and cause of death.

Unit 2: Co-evolution of insects and plants 5 hrs

Insect-plant relationships, Mechanisms of insect resistance in plants, Tri-trophic interactions (Plant-insect pest-natural enemies).

Unit 3: Bionomics of Insect Pests of Agricultural Crops and Stored grains 12 hrs

Pest, Economic threshold (ET), Economic injury level (EIL), classification of pests; Identification, seasonal history, nature of damage, life history and control of pests of rice: *Leptocorisa acuta;* pulses: *Helicoverpa armigera*; Sugarcane: *Scirpophaga nivella*; Cotton: *Earias vitella*; Vegetables: *Raphidopalpa foveicollis*; Fruits: *Papilio demoleus*, Stored grains: *Sitophilus oryzae*, *Corcyra cephalonica*, *Callosobruchus chinensis*.

Unit 4: Bionomics of Insect pests of Medical and Household importance and Pest Management Methods 18 hrs

Bionomics and management of mosquitoes, lice, fleas, house fly, cockroach, and termites. Physical, Cultural, Chemical, Biological, Microbial, Genetic (SIT, F_1 sterility, etc.), Biotechnological, and Bio-rational methods (using pheromones, JH mimics, MH agonists, etc.) in pest management. Integrated Pest Management (IPM) and Integrated Vector Management (IVM).

PRACTICALS: (30 hrs)

(Laboratory periods: 15 classes of 2 hours each)

1. **Study of morphology, growth and development of insect pests**
   (a) Rearing of a hemimetabolous [(e.g. Red cotton bug, *Dysdercus keonigii*)/ holometabolous (e.g. pulse beetle, *Callosobruchus chinensis*)] insect pest in the laboratory. Submission of life cycle stages and details on its biology, economic importance, and appropriate pest management method.
   (b) Study of life history stages of insect pests of medical and household importance – mosquitoes (*Anopheles, Culex*, *Aedes*), lice, sand fly, flea, house fly, cockroach (*any four*). Submission of life cycle stages and details on its biology, economic importance, and appropriate pest management method.

1. **Insect Toxicology:**
   (a) Estimation of LD_{50} and LC_{50} of insecticides using mosquito larvae/ given data.
   (b) Pesticide residue analysis of contaminated soil/vegetable/water samples using TLC.

Project work/ Field visits

1. Field survey of beneficial insects and insect pests. Submission of geo-tagged photographs captured in different locations, with details of field observations.

2. Visit to the institutional labs and/or fields. Submission of a lab. visit/field report.

Essential/recommended readings:

- Atwal, A.S. (1993) Agricultural Pests of India and South East Asia. Kalyani Publishers, New Delhi.
- Dennis, S. Hill (2005). Agricultural Insect Pests of the Tropics and Their Management, Cambridge University press.
- Metcalf, C. L., Flint, W.P. and R.L. Metcalf (1962). Destructive and Useful Insects: their habits and control, 4th Ed. Mc Graw-Hill.
- Pedigo, L. P. (2002). Entomology & Pest Management, Prentice Hall, New Jersey, USA.
- Service, M. (2012). Medical Entomology for students, Cambridge University Press, UK.

Suggested Readings:

- S. Pradhan (1998) (Reprint 2023). Insect Pest of Crops. National Book Trust, New Delhi.
- Schoonhoven, L. M., van Loon, J.A., & Dicke, M. Insect Plant Biology (2005). Oxford University Press, USA.
- Jolivet, P. (1998). Interrelationship between insects and Plants, CRC Press, USA.
- Norris, Caswell-Chen and Kogan, M. (2002). Concepts of IPM, Prentice-Hall, USA.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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SEMESTER –VIII

SEMESTER	DISCIPLINE SPECIFIC CORE COURSE (DSC)	DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)
VIII	ZOO-DSC-20: Comparative Physiology of Vertebrates	Zoo -DSE-21: Evolutionary Immunobiology of Animals*
		Zoo -DSE-22: Reproductive Endocrinology
		Zoo -DSE-23: Faunal Conservation and Restoration

***Mandatory DSE to be offered in Semester VIII**

DISCIPLINE SPECIFIC CORE COURSE -20

Comparative Physiology of Vertebrates

Zoo-DSC-20

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Comparative Physiology of Vertebrates **Zoo-DSC-20**	04	02	Nil	02	Should have appeared in Semester VII	

Learning objectives:

This course focuses on:

- understanding the physiological mechanisms that enable vertebrates to adapt and evolve over time.
- exploring how different vertebrates, from fish to mammals, have developed unique physiological adaptations to meet the demands of their environments.

Learning outcomes:

At the end of this course students should be able to:

- Learn the significance of variations in the digestive system based on different diets.
- Understand the mechanisms of extracting oxygen from the environment using different respiratory structures.
- Appreciate the design of the cardiovascular system in different vertebrates as an efficient gas transport mechanism.
- Appreciate the variations in the reproductive strategies in accordance with the environment.
- Understand the various strategies for maintaining a steady physiological state and respond to extreme environmental conditions.

SYLLABUS OF DSC-20

THEORY **(30 hrs)**

Unit 1: Physiological Processes **16 hrs**
Digestion: Monogastric, digastric and polygastric digestive systems**; Respiration:** Gills, swim bladder, skin and lungs as respiratory organs; **Circulation:** Single-circuit and double-circuit circulatory designs**; Reproduction:** Reproductive Cycles in seasonal and non- seasonal breeders.

Unit 2: Homeostasis **10 hrs**
Osmoregulation in freshwater, marine and terrestrial vertebrates. Thermoregulation in poikilotherms and homeotherms.

Unit 3: Adaptations **4 hrs**
Physiological responses to specific environmental challenges, like desert conditions, high altitude and starvation.

PRACTICALS **(60 hrs)**
(Laboratory periods: 15 classes of 4 hours each)

1. Physiological Response of *Drosophila*/fish/stored grain pests to environmental stressors like temperature extremes/starvation.
2. Comparison of Hemoglobin content of fish blood in fish kept in normal and low-oxygen water.
3. Comparison of blood cells in a blood smear of a fish and human.
4. Study of the Estrous cycle of rats through permanent slides of vaginal smears during different phases of the cycle.

PROJECT WORK

Project report (group activity) on effect of exercise/ yoga/meditation/adequate sleep/excessive mobile gaming on cardiovascular health (Heart rate, BP and SpO2 using pulse oximetry) to be submitted at the end of the semester.

Essential/Recommended Readings:

1. How Animals work by Knut Schmidt-Nielsen, Cambridge University Press
2. Animal Physiology: Adaptation and Environment by Knut Schmidt-Nielsen, Cambridge University Press

Suggested Readings:

1. Animal Physiology by Hill et al, Sinauer Associates Inc.
2. Environmental Physiology of Animals by Willmer et al, John Wiley (original)
3. Principles of General and comparative physiology by Carpenter, W B, Forgotten Books.
4. Experiments with *Drosophila* for Biology courses (ebook) by Lakhotia, SC, Indian National Academy of Sciences.
5. Manual of Experimental Ichthyology by Gahlawat, SK et al, Daya Publishing House.
6. Cardiopulmonary Exercise testing and cardiovascular health by Karlman Waserman, Wiley-Blackwell.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -21
Evolutionary Immunobiology of Animals
Zoo-DSE-21

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Evolutionary Immunobiology of Animals **ZOO-DSE-21**	4	3	Nil	1	Should have appeared in Semester VII	

Learning Objectives

The Learning Objectives of this course are as follows:

- To improve basic understanding about evolution of the immune system in different animals and group specific immunological adaptations.
- To increase student understanding about the evolution of complexity in the immune system as well as immunological repertoire among animals.
- To help students analyze immunological manifestations during experimentation and research.

The Learning Outcomes of this course are as follows:

After studying this course, learners can:

- Understand the basic organization of the immune system among different groups of animals.
- Gain knowledge about the evolution of primitive forms of the immune system and their functioning among invertebrates.
- Enhance student proficiency in understanding of immune system organization and their pathology in perturbation.

SYLLABUS OF DSC-21

THEORY **(45 hrs)**

Unit 1: Evolution of innate immunity **15 hrs**

Basics of unicellular to metazoan immunity, evolution of immunological armament across the animal phyla, hematopoiesis and functions of hemocytes in invertebrates (Insects, Crustaceans, Mollusks and Tunicates) humoral factors of tunicates. Evolution of Drosophila Toll-1 receptors and mammalian Toll-like receptors and antimicrobial host-defense of Drosophila.

Unit 2: Evolution of adaptive immunity 14 hrs

Origin and evolution of adaptive immunity in animals, a comparative account of lymphocyte development in vertebrates, humoral and cell mediated immunity in vertebrates, recognition of self/non-self, development of immunological memory. Major lymphoid organs and their distribution in fishes, nonspecific defense reaction of fishes. Peripheral lymphoid organs CALT, GALT, BALT, HALT and mural nodules in birds and other vertebrates.

Unit 3: Evolution of Cytokines in Vertebrates 08 hrs

Evolutionary Diversification of Cytokines. Pro-inflammatory, inflammatory and antimicrobial mediators of vertebrates and their functions.

Unit 4: Major Histocompatibility Complex 08 hrs

Genomic organization of MHC genes in vertebrates, evolution of Major Histocompatibility Complex in Teleosts.

PRACTICALS (30 hrs)

(Laboratory periods: 15 classes of 2 hours each)

1. Identification of organs of the immune system in Fishes, Amphibians, Aves and Mammals through slides/photographs.
2. Histological study of organs of the immune system of vertebrates.
3. Staining and identification of plasmatocytes of *Drosophila*.
4. Identification of different types of cells in the stained blood smears of Fish/Frog.
5. Study of techniques for the identification and quantification of cytokines and their expression.

Essential/Recommended readings

1. Evolutionary Concepts in Immunology by Robert Jack, Louis Du Pasquier. Publisher: Springer Nature Switzerland.
2. Evolution and Comparative Immunology of Immune Systems in Marine Organisms by Gyri T. Haugland, Sissel Jentoft, Monica Hongroe Solbakken. Publisher: Frontiers.

Suggested readings

1. The Evolution of the Immune System Conservation and Diversification by Davide Malagoli. Publisher: Academic Press.
2. Roitt's Essential Immunology by Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt. Publisher: Wiley.
3. Veterinary Immunology by Ian R. Tizard. Publisher: Elsevier.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE- 22
Faunal Conservation and Restoration
Zoo-DSE-22

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Faunal Conservation and Restoration **Zoo-DSE-22**	4	3	Nil	1	Should have appeared in Semester VII	

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the faunal diversity in context to the Indian sub-continent, and recognise it as an integral part of global ecosystem.
- To understand theoretical concepts, ethical principles and legal frameworks governing animal conservation.
- To expose students to the various threats to biodiversity.
- To identify contemporary issues related to wildlife conservation such as habitat loss, poaching, climate change, or biodiversity decline.
- To have an in-depth exploration of different strategies used in faunal conservation, such as protected areas, captive breeding, rewilding, or community-based conservation.

Learning Outcomes

After studying this course, learner can:

- Understand the ethical, historical, and cross-cultural context of environmental issues related to fauna.
- Provide novel perspectives or solutions to conserve faunal species.
- Provide proposals for future research, policy changes, or conservation laws.

SYLLABUS OF DSC-22

THEORY (45 hrs)

Unit 1: Fundamentals of biodiversity 5 hrs

Species diversity, genetic diversity and ecosystem diversity. Faunal biodiversity hotspots of India: Himalayan region, western ghats and north-eastern region. Sentinel species/ environmental guardians.

Unit 2: Valuing biodiversity, Social issues and environment 11 hrs

Ecological economics, Ethical values, Evaluating development projects (any project of India). Global issues and sustainable development; Biodiversity crisis: how biodiversity is interconnected with ecosystem processes, and it's decline with emphasis on impact on human health. Release of GMOs in the environment.

Unit 3: Threats to biodiversity 14 hrs

Pollution Ecology: Air, water, soil and radioactive. Emerging contaminants. Habitat destruction, fragmentation and degradation; Overexploitation. Global climate change, acid rain; Invasion Ecology; Ecotoxicology. Wildlife forensics- forensic protocols for species identification from different parts of reptiles, birds and mammals; wildlife crime case studies.

Unit 4: Conservation Restoration 15 hrs

Sustainable utilization of natural resources; Bioprospecting; People biodiversity register; Role of indigenous knowledge system; Ecological footprinting; Protected areas; Policies and laws; Environmental impact assessment; GIS and remote sensing. Factors involved in implementing ecological restoration: Restoration of major communities; Bioremediation.

PRACTICALS (30 hrs)

(Laboratory periods: 15 classes of 2 hours each)

1. To study pollutants: phosphate, nitrates, sulphates in the water sample (control and polluted)
2. To analyze and compare phosphorus, nitrogen, organic matter, particle size of the soil samples.
3. To perform toxicological bioassay tests: LC50/ EC50 on organisms such as zooplankton, stored grain pests etc.
4. Study any eight endangered animal species of India with focus on their conservation efforts
5. To study principle of Global Positioning System (GPS) and Geographic Information System (GIS)

PROJECT WORK
Project Report on hypothesizing and designing experiment based on field or laboratory visit

Essential/Recommended Readings:

1. Richard, B. Primack, Essentials of Conservation Biology. (6th edition), Sinauer Associates.
2. Gabriel, M. Biodiversity and Conservation, Oxford and IBH Publishing.

3. Sharma, P.D., Ecology and Environment, Rastogi Publications.
4. Nair, S.M. Endangered Animals of India and their Conservation, National Book Trust of India.
5. Joseph, B., Environmental studies, Tata Mc Graw Hill.
6. Ghosh, S.K., Singh, R. 2003. Social Forestry and Forest Management. Global Vision Pub.
7. Sinha, S. 2010. Handbook on Wildlife Law Enforcement in India. TRAFFIC, India.

Suggested Readings:

1. Mohapatra Textbook of Environmental Biotechnology, IK Publication.
2. Thakur, I. S., Environmental Biotechnology, IK Publication.
3. Divan Rosencraz, Environmental Laws and Policies in India, Oxford Publication.
4. Allabay, M., Basics of Environmental Science, Routledge Press.
5. Rana SVS, Environmental pollution – Health and Toxicology, Narosa Publication.
6. Miller, G.T. 2002. Sustaining the Earth, an Integrated Approach. (5th edition) Books/Cole, Thompson Learning, Inc.
7. Chapman, J.L., Reiss, M.J. 1999. Ecology: Principles and Applications (2nd edition) Cambridge University Press.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE- 23
Reproductive Endocrinology
Zoo-DSE-23

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Reproductive Endocrinology **Zoo-DSE-23**	4	3	Nil	1	Should have appeared in Semester VII	

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize students with the reproductive anatomy, physiology and endocrinology of males and females.
- To introduce and discuss the interrelationships between reproductive hormones produced by the brain and reproductive glands and how they interact to control the reproductive processes like pregnancy, parturition and lactation.
- To introduce and discuss reproductive management practices and understand endocrine disorders.

Learning Outcomes

At the end of this course students should be able to:

- Appreciate the reproductive anatomy
- Learn the significance of physiology of the reproductive system, pregnancy and post pregnancy.
- Understand the various reproductive disorders

SYLLABUS OF DSC-23

THEORY **(45 hrs)**

Unit 1: Reproductive Anatomy- Male Reproductive System **10 hrs**

Primary and accessory sex organs and secondary sex characters. Histology of testis. Endocrine functions of testis. Spermatogenesis. Hypothalamic control of testicular functions.

Unit 2: Reproductive Anatomy- Female Reproductive System 15 hrs

Histology of ovary. Ovarian hormones and their functions. Oogenesis and ovulation. Formation and functions of corpus luteum. Hypothalamic control of ovarian functions. Menstrual cycle and its regulation. Abnormalities in menstrual cycle. Onset of menopause and postmenopausal changes.

Unit 3: Physiology of Pregnancy, parturition and lactation 10 hrs

Structure and functions of placenta. Maintenance of pregnancy and role of hormones. Development of mammary gland and lactation - role of hormones. Parturition. Pregnancy tests. Development of mammary glands, lactation and their hormonal control.

Unit 4: Reproductive Disorders 10 hrs

Sexual differentiation & developmental abnormalities – male & female Menstrual disorders – Precocious, delayed or absent puberty; Amenorrhea Fertility disorders – Sexual dysfunction; Infertility; Spontaneous pregnancy loss Pregnancy disorders – Pre-eclampsia, IUGR, Labour abnormalities Endocrine disorders – Hyperprolactinemia Autoimmune Disorders Genetic disorders (mutations and syndromes) Cancers and biomarkers – Testicular; Prostate; Ovarian; Endometrial; Cervical and Breast.

PRACTICALS (30 hrs)

(Laboratory periods: 15 classes of 2 hours each)

1. To study surgical techniques via videos 1. Ovariectomy 2. Castration.
2. Histological and histochemical techniques - Study of the different phases of the estrous cycle of rat using permanent slides of its vaginal smears during the different stages of the cycle.
3. To study sections of ovary, uterus, fallopian tube, testis, epididymis.
4. Study of Sperm count and motility and effect of some antifertility agents.
5. Study of modern contraceptive devices.

PROJECT WORK

Project report on survey of reproductive health in any small human community.

Essential/Recommended Readings:

1. Endocrinology, Mac E. Hadley, Pearson Education.
2. Vander's Human Physiology, E.P. Widmaier et al., McGraw-Hill, Higher Education.
3. Endocrinology. Vols. I, II and III by L.O. DeGroot. W.B. Saunders Co.

Suggested Readings:

1. Human Physiology: An Integrated Approach by D.U. Silverthorn, Pearson.
2. Medical Physiology, A.B. Singha Mahapatra, Current Books International.
3. "Pathways to Pregnancy and Parturition" (3rd Edition 2012, P. L. Senger)

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Science (Prog.) in Applied Life Sciences

Agrochemicals and Pest Management

SEMESTER-VII

ZOOLOGY

DISCIPLINE SPECIFIC CORE COURSE: **ALS-ZOO DSC 07**

INSECT BEHAVIOUR

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE- REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practicals/ Practice		
Insect Behaviour **ALS ZOO DSC 07**	4	2	Nil	2	Appeared in Sem-VI	NA

Learning Objectives:

- This syllabus provides a comprehensive overview of insect behavior, its underlying mechanisms, and its relevance to various fields.
- Insect behaviour is a scientific study of the behaviour of insects in their natural habitat and in relation to their interactions with other living organisms and the environment.
- Study of orientation, feeding and oviposition behaviour of insects has immense applications in pest management in an effective, economical and eco-friendly manner.
- Behavioural studies can be conducted easily by the undergraduate students in the laboratory and can later be extrapolated in the investigative field projects.

Course Outcomes:

Upon completion of the course, the students will be able to:

- Learn about the concept of insect behaviour and its applications
- Gain knowledge about importance of insect behaviour in natural habitat.
- Understand the complexities of insect behavior and its applications in the real world.
- Understand the difference between various types of pests and their host plants, extent of damage caused by them.

Theory **30h**

Unit 1: Introduction to insect behaviour **5 h**

Scope and importance of studying insect behavior. Types of behaviour: Innate, Learned, Fixed Action patterns (FAPs) and Complex behaviours (Altruism).

Unit 2: Mechanism of sensory perception and Orientation behaviour of insects **10 h**

Sensory perception in insects: mechanoreceptors, hygroreceptors, thermoreceptors, photoreceptors. Visual Communication, Acoustic communication, Tactile communication and Chemical communication, Neuronal and hormonal basis of Insect behaviour, Orientational responses: Kinesis and Taxis.

Unit 3: Feeding behavior of insects

Types of feeding habits with special emphasis on phytophagous insects, Insect-plant relationships, Foraging behaviour of Honey bees. **8 h**

Unit 4: Reproductive behavior

Locating mates, Courtship, Sexual differences in mating behavior, Mate selection and rejection, Genetic quality and mate choice, Aggregation signal, Sex pheromones. **7 h**

Practicals

(Laboratory periods 15 classes of 4 hrs each)

1. To study the various tools and techniques/methods used to study of the behaviour of insects in the laboratory and field conditions.
2. To observe the insects in the wild.
3. To distinguish between beneficial and destructive insects (pests).
4. To study the geotaxis behaviour of soil insects.
5. To study the phototaxis behaviour larvae of phytophagous insects.
6. To study the stridulation, swarming, habituation, courtship behaviour of insects (at least two videos for each behaviour).
7. Construction of ethogram by using suitable data to study insect behaviour.
8. Visit to forest, wildlife park, sanctuary, zoological park to study and record the behaviour of insects and prepare a short report.

Suggested Readings:

1. V.B. Awasthi. Principle of Insect Behaviour. Scientific Publication; 2nd Edition.
2. Mathews, W. Robert and Methews, R. Janice. Insect Behaviour. Springer, 2nd Edition.

3. Alcock, John. Animal Behaviour. Sinauer Associates. 11th Edition.

Additional Resources:

1. UGC INFONET / DU E-Resources & SciFinder Web Version registration
2. Viji, C. P., Phani Kumar, K. and Sudhavan Vani, V. Insect Ecology and Behaviour.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SCIENTFIC ELECTIVE COURSE: **ALS- ZOO DSE 06**

SOCIAL AND BENEFICIAL INSECTS

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practicals/ Practice		
Social and Beneficial Insects **ALS ZOO DSE 06**	4	2	Nil	2	Appeared in Sem-VI	NA

Learning Objectives:

The learning objectives of this course are as follows:

- to acquaint students of the social organization found in insects.
- to apprise them of beneficial aspects of insects.
- to impart knowledge about the techniques involved in culturing and rearing of bees,

silkworms and lac insect.

Learning Outcomes:

By studying this course, students will be able to:

- identify different types of social and beneficial insects.
- differentiate the various castes and their role in the social life of insects.
- acquire skill for mass rearing of beneficial insects and their products.

Theory **30h**

Unit 1: Social Insects **7h**

Characteristics and systematic position. Social organization: caste determination, communication, social parasitism and symbioses, social insect pathogens. Life cycle, social organization and types of ants, bees, wasps and termites.

Unit 2: Apiculture **7h**

Habit and habitat of honey bee (Apis), bee keeping techniques, bee pasturage, artificial bee hives. Economic importance of bee. Bee enemies, bee diseases and their control.

Unit 3: Sericulture and Lac Culture **11 h**

Life cycle of silkworm Bombyx mori. Types of silkworm species and their salient features. Rearing techniques of mulberry, muga, eri and tassar silkworms. Enemies and diseases of silkworms and their management.

Habit, habitat and biology of *Laccifera lacca*. Host trees of lac insect, pruning, inoculation and lac harvesting. Enemies of lac insect and their control

Unit 4: Ecological aspects of beneficial insects **5h**

Ecological role of insects: pollination, weed control, improving soil fertility and as scavengers. Medicinal use of insects and insect products. Entomophagy.

PRACTICALS **60 h**

1. Study of life cycle of ants, bees, termites, silk worm and lac insect through museum specimens/photographs.
2. Study of different nests build by ants, bees and termites.
3. Construction and maintenance of artificial bee hives and study of equipments related to apiculture.
4. Rearing techniques of mulberry, muga, eri and tassar silkworms.
5. Study of different types of enemies and diseases of silkworms.
6. Study of lac culture technique: pruning, inoculation, cropping and harvesting.
7. Study of economically important insect products.

Essential/Recommended readings:

1. Watson, J. A. L., Okot-Kother, B. M. and Noiroh C. (1985) Caste differentiation in social insects. Pergamon Press.
2. Dunston AP. (2007) The Insects: Beneficial and Harmful Aspects.Kalyani Publishers., New Delhi.
3. Brian, M. V. (1983) Social insects: ecology and behavioural biology. Chapman and Hall, London, New York.
4. D. B. Tembhare (2017) Modern Entomology. Himalaya Publishing House.

5. Dokuhon, Z.S. (1998) Illustrated Textbook on Sericulture. Oxford & IBH publishing Co., Pvt. Ltd. Calcutta.
6. Shukla, G.S. and Upadhyay, V.B. (2014) Applied and Economic Zoology, Rastogi Publications.

Suggested Readings:

1. Maxwell F.G. and Jennings P.R. (Eds). (1980) Breeding Plants Resistant to Insects. John Wiley & Sons, New York.
2. Encyclopedia of Social Insects (2021) Springer International Publishing.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SCIENTFIC ELECTIVE COURSE: **ALS ZOO DSE-07**

BASICS OF CHRONOBIOLOGY

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practicals / Practice		
Basics of chronobiology ALS ZOO DSE 07	**4**	**2**	**Nil**	**2**	**Appeared in Sem-VI**	NA

Learning Objectives

The learning objectives of this course are as follows:

- to understand the cyclic physiological phenomena.
- to learn about the unique phenomena of seasonal migration and hibernation.
- to expose the students to clock dysfunctions.
- to make the students aware of the various aspects of chronobiology and its application in therapeutics and medicine
- to enable the students to learn about their own rhythms of sleep and body temperature
- Summarize the importance of various biological rhythm in nature.

Learning Outcomes

By studying this course, students will be able to

- Understand the concepts of biological significance of biological rhythms
- Acquaint with the patterns of animal behaviour and importance of circadian rhythms.
- Observe the adaptations in various animals.
- Develop an overview of the principles of chronobiology.
- Molecular mechanisms underlying the generation of circadian time
- study about the applications of chronobiology in medicine, pharmacology and therapeutics.

- **Theory** **30h**

UNIT- 1: Introduction to Chronobiology **12 h**

Milestone and scope of chronobiology; Types and properties of Rhythms – Ultradian rhythms, Circadian rhythms, Infradian rhythms; Lunar rhythm; Circannual rhythm. Characteristics of circadian rhythms, Temperature compensation; Masking and synchronization; Zeitgebers- Photic and non-photic Zeitgebers.

UNIT- 2: Biological clock system **8 h**

Characteristics, Input, time generation and output components; Central and peripheral clocks; Suprachiasmatic nucleus; Molecular mechanisms underlying the generation of circadian time in Drosophila.

UNIT- 3: Circannual rhythm and Photoperiodism **10 h**

Circannual rhythms; Photoperiodism and regulation of seasonal breeding animals in vertebrates; Pineal as photoreceptive structure in non-mammalian vertebrates. Seasonal Migration in birds; Role of melatonin and serotonin.

UNIT- 4: Circadian rhythms and human health. **10 h**

Circadian clock and sleep-wake cycle; Jet Lag, Shift work ; Sleep and Chronotypes; Consequence of clock dysfunction- Sleep Disorders, Depression, Anxiety, Stress, Cancer; Obesity, Immune Disorders; Chronopharmacology, Chronomedicine and Chronotherapy.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of characteristics of circadian rhythms from a given dataset.
2. Ambulatory blood pressure monitoring and biological rhythm analysis.
3. Using periodically assembled data study of body temperature rhythm.
4. Study of circadian functions in humans (daily eating, sleep and temperature patterns).
5. Human chronotypes-MCTQ questionnaire and analysis.
6. Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

Essential/recommended readings

1. Binkley, S. (2020). Biological clocks: Your owner's manual. CRC Press.

2. Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. DeCoursey (ed). 2004, Chronobiology Biological Timekeeping: J, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
3. Koukkari, W. L., & Sothern, R. B. (2007). Introducing biological rhythms: A primer on the temporal organization of life, with implications for health, society, reproduction, and the natural environment. Springer Science & Business Media.

SUGGESTED readings

1. Palmer, J. D. (2002). The living clock: The orchestrator of biological rhythms. OxfordUniversity Press.
2. Dunlap J. C, Loros J. J, DeCoursey P. J. (2004) Chronobiology Biological Time keeping. Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
3. Saunders D. S. (2002). Insect Clocks. III Edition, Barens and Noble Inc. New York, USA

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 08**

NON-INSECT PESTS AND THEIR CONTROL

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practicals / Practice		
Non-insect pests and their control ALS ZOO DSE 08	4	2	Nil	2	Appeared in Sem-VI	NA

Learning Objectives:

The learning objectives of this course are as follows:

- to introduce students with various types of non-insect pests in agriculture and household.
- to give an understanding of their behaviour and the damage they cause to crops
- to acquaint with various plant economic losses caused by non-insect pests.

Learning Outcomes:

By studying this course, the students will be able to:

- recognize major non-insect pests in Indian subcontinent.
- identify the specific life stage of the pest which causes significant loss to crop plants and adopt appropriate measures to control them.

Theory **30h**

Unit 1: Introduction to non-insect pests and their management **8 h**

Introduction, habit and habitat and economic importance of non-insect pests and their management. Major mite pests of cultivated and plantation crops, Economic importance along with their management strategies. Study of Red spider mite (*Tetranychus neocaledonicus*) and Cereal rust mite (*Abacarus hystrix*), its damage on different crops and control measures.

Unit 2: Damage to crops by Molluscs and and their control **7 h**

Important species of snails and slugs as pest in India. Description of their nature of damage on agricultural crops, fruits, vegetables and ornamental plants in coastal area. Study of *Helix* sp and Indian slug species (*Macrochlymus indica*)**.** Strategies for their management.

Unit 3: Nematodes as pests of crops and their control **7 h**

Habitat, general characteristics and management of major phyto-nematodes. Study of Root-knot nematode (*Meloidogyne incognita*) and cyst nematode (*Heterodera rostochiensis)*, its impact on crops and control measures.

Unit 4: Damage to crops by the pests and their management **8 h**

Study of important bird pests of agricultural crops and their control: Rose ringed parakeet (*Psittacula krameri*) and blue rock pigeon (*Columba livia*); damage caused by them and their management. Status of rodents as pest in India. Important species of rodents. Study of Indian mole-rat (*Bandicota bengalensis*), palm ***squirrel*** (*Funambulus palmarum*) and Indian fruit bat (*Pteropus giganteus*) with its nature of damage and control measure.

<u>Practicals</u> **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. Identification, life cycle and damage caused by following mites *with specimen/Photograph:*
Red spider mite (*Tetranychus neocaledonicus*), Cereal rust mite (*Abacarus hystrix),* Broad mite (*Polyphagotarsonemus latus*)

2. Identification and damage caused by of the following molluscan *with specimen/Photograph:*
Common snail, *Helix* spp and Indian slug (*Macrochlymus indica*)

3. Identification and damage caused by of the following nematode *with specimen/Photograph:*
Root-knot nematode (*Meloidogyne incognita*), cyst nematode (*Heterodera rostochiensis)* and Wheat-gall nematode (*Anguina tritici*)

4. Identification and damage caused by of the following Birds *with specimen/Photograph:*
Rose ringed parakeet (*Psittacula krameria*) and blue rock pigeon (*Columba livia*)

5.Identification and damage caused by of the following mammals *with specimen/Photograph:*
Indian mole-rat (*Bandicota bengalensis*), Commonrat (*Rattus rattus*), palm ***squirrel*** (*Funambulus palmarum*), Indian fruit bat (*Pteropus giganteus*) and common monkey (*Macaca mulatta*)

6. To visit any agriculture Institute and make a project report on main agriculture crops pest and its management.

Essential/recommended readings

1. Dhaliwal, G.S. (2009). *An Outline of Entomology* (2nd Ed.). Kalyani Publishers.
2. Atwal A.S. &Dhaliwal G.S. (2015) *Agricultural pests of south Asia and their management* (8th ed.). Kalyani Publishers.

Suggested readings

1. Devasahayam H.L (2011) *Practicals Manual of Entomology: Insects and Non-insect Pests*. New India Publishing Agency.

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DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 09**

MODERN TOOLS AND TECHNIQUES FOR ENTOMOLOGICAL RESEARCH

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practicals/ Practice		
Modern tools and Techniques for Entomological research **ALS ZOO DSE 09**	4	2	Nil	2	Appeared in Sem-VI	

Learning Objectives:

The learning objectives of this course are as follows:

- To understand modern techniques used in biotechnology for research, diagnostics, and industrial applications.
- To learn the principles, applications, and limitations of bioinstrumentation methods.
- To gain hands-on experience in the operation and maintenance of advanced instruments.
- To develop critical thinking to select and apply suitable techniques for solving specific biological problems.
- To learn to interpret experimental data and troubleshoot issues in instrumentation.

Learning Outcomes:

By studying this course, students will be able to:

- Gain a better understanding of diverse cellular processes and cellular interactions.
- Explain the principles and working mechanisms of advanced instruments in biotechnology.
- Demonstrate proficiency in operating instruments such as spectrophotometers, chromatographs, and PCR machines.
- Design experiments using advanced techniques like chromatography, electrophoresis, and mass spectrometry.
- Analyze experimental data generated by advanced bioinstrumentation.

- to apply biotechnological tools to solve problems in diagnostics, genomics, proteomics, and drug discovery.

Theory: 30h

UNIT-1: Overview of Basic instruments used in Entomology laboratory 4 h

Microscopes: Principles and applications of various microscopes, Laminar-Flow Hood, Autoclave, Centrifuge, Hamocytometer, Incubator, Cryostorage Container, pH meter. 2 h

UNIT-2: Spectroscopic Techniques 8 h

Principles and Applications: UV-Visible spectroscopy, Fluorescence spectroscopy, Advanced Techniques: Infrared (IR) spectroscopy, Atomic Absorption Spectroscopy (AAS), and Nuclear Magnetic Resonance (NMR). Applications: Structure determination, protein folding studies and biomolecular interactions.

UNIT-4: Chromatography and Electrophoresis 6 h

Chromatography: Principles, instrumentation, and applications of HPLC, Gas Chromatography (GC), and Ion Exchange Chromatography. Electrophoresis: Polyacrylamide Gel Electrophoresis (PAGE), Agarose Gel Electrophoresis, 2D Gel Electrophoresis. Applications in genomics and proteomics. Mass Spectrometry (MS): Principles, instrumentation, and applications.

UNIT-4: Molecular Biology Techniques 10 h

Polymerase Chain Reaction (PCR): qPCR, RT-PCR, and digital PCR. DNA Sequencing: Sanger sequencing and Next-Generation Sequencing (NGS). CRISPR-Cas9 Technology: Gene editing and applications. Biosensors: Principles, components, and applications in diagnostics.

Practicals 60 h

(Laboratory periods:15classes of 4 hours each)

1. Chromatography Techniques: Separation of biomolecules using Chromatography.

2. Electrophoresis techniques: SDS-PAGE for protein separation.

3. Amplification of DNA. Gel documentation and analysis of PCR products.

4, Imaging Techniques: Demonstration of SEM/TEM.

5. Biosensors: Demonstration of glucose biosensors and ELISA techniques.

Project related to topics covered in theory/ project report based on visit to labs/ institutions/industry.

Essential/recommended readings

1. Principles and Techniques of Biochemistry and Molecular Biologyby Keith Wilson and John Walker, 7th Edition (2010), Cambridge University Press.
2. Biophysical Chemistry: Principles and Techniques by Upadhyay, Upadhyay, and Nath, Revised Edition (2020), Himalaya Publishing.

3. IntroductiontoSpectroscopybyDonaldL.Paviaetal,5th Edition (2015), Cengage Learning.
4. Bioinstrumentation by John G. Webster,1st Edition (2004), Wiley-Interscience.

Suggested readings

1. Fundamentals of Analytical Chemistry by Douglas A. Skoog et al., 9th Edition (2013), Cengage Learning.
2. Molecular Biology of the Gene by James D. Watson etal., 7th Edition (2013), Pearson.
3. Chromatography: Principles and Instrumentation byB.K. Sharma, Revised Edition (2007), Goel Publishing House.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Science (Prog.) in Applied Life Sciences

Agrochemicals and Pest Management

SEMESTER-VIII

ZOOLOGY COMPONENT

DISCIPLINE SPECIFIC CORE COURSE: **ALS ZOO DSC 08**

CONCEPT OF EVOLUTIONARY BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE- REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practicals/ Practice		
Concept of Evolutionary Biology ALS ZOO DSC 08	4	2	Nil	2	Appeared in Sem-VII	NA

Learning Objectives:

- The learning objectives of this course are as follows:
- To understand evolutionary forces leading to the variations and diversification of species.
- To learn about deciphering evidences ranging from fossil records to molecular data and to establish phylogenetic relationships of species.
- To gain knowledge of the processes and patterns of biological evolution.
- To get acquainted with origin and evolution of man.
- To acquire problem solving and high order analytical skills by attempting numerical problems as well as performing simulation studies of various evolutionary forces in action.

Learning Outcomes:

By studying this course, students will be able to:

- To gain knowledge about the relationship of the evolution of various species and the environment they live in.

- To apply the knowledge gained on populations in real time, while studying speciation, behaviour and susceptibility to diseases.
- To have a better understanding of the variations and genetic drift to ensure that conservation efforts for small, threatened populations are focused in right direction.
- To predict the Practicals implications of various evolutionary forces acting on the insect population in the field of human health, agriculture and wildlife conservation.

<u>Theory</u> **30 h**

Unit- 1 Origin of life and Historical Review of Evolutionary Concepts. **8 h**

Lamarckism, Darwinism, Neo-Darwinism, Chemogeny, RNA world, biogeny, origin of photosynthesis, endo-symbiotic theory

Unit- 2: Evidences of Evolution **4 h**

Palaeontological Evidences: geological time scale, Origin and Evolution of Insects; Molecular Evidences: neutral theory of evolution, molecular clock

Unit-3: Causes and Mechanism of Organic Evolution **9 h**

Variations: Heritable variations and their role in evolution. Natural selection, types of natural selection, artificial selection, kin selection, adaptive resemblances, sexual selection, frequency dependent selection. Natural selection (concept of fitness, selection coefficient), genetic drift (founder's effect, bottleneck phenomenon), migration and mutation (genetic load).

Unit-4: Species, Speciation and Extinction **5 h**

Speciation micro-evolutionary changes (inter-population variations, clines, Ring species, races), species concept, isolating mechanisms. **4 h**

Mass extinctions (events, causes and effects), Detailed explanation of K-T extinction

Practicals **60 hrs**

(Laboratory periods: 15 classes of 4 hrs each)

1. Study of fossils (types, forms and dating) from models/pictures.
2. Study of homology, analogy and homoplasy from suitable specimens.
3. Study of different modes of speciation and adaptive radiation/macroevolution using suitable examples.

4. Study of variations in a sample human population: (a) Continuous variation: Height/Weight in relation to age and sex (b) Discontinuous variation: Ability/Inability to taste Phenylthiocarbamide (PTC).
5. Study of Hardy-Weinberg Equilibrium: statement, assumptions, derivation of the equation and its verification by chi square analysis.
6. Demonstration of role of natural selection and genetic drift in changing allelic frequencies using simulation studies.

Suggested Readings:

1. Roberts, A. (2018) Evolution: the human story, Dorling, Kindersley Ltd.
2. Hall, B.K. and Hallgrimson, B. (2013). Evolution. V Edition, Jones and Barlett Publishers.
3. Campbell, N.A. and Reece J.B. (2011). Biology. IX Edition. Pearson, Benjamin, Cummings. 4. Barton N.H., Briggs D.E.G., Eisen J.A., Goldstein D.B. and Patel N.H., (2007) 1st Ed. Evolution, Cold Spring Harbor Laboratory Press.

Additional Resources:

1. Futuyma, Douglas and Mark, Kirkpatrick (2017) 3rd Ed. Evolutionary Biology, Oxford University Press.
2. Zimmer C. and Emlen D. J., (2013) 1stEd. Evolution: Making Sense of Life, Roberts & Co.
3. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition, Wiley Blackwell.
4. Ridley, M. (2004). Evolution. III Edition, Blackwell publishing.
5. UGC INFONET / DU E-Resources & SciFinder Web Version registration

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 10**

MEDICAL AND VETERINARY PESTS

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practicals/ Practice		
Medical and Veterinary pests **ALS ZOO DSE 10**	**4**	**2**	**Nil**	**2**	**Appeared in Sem-VII**	**NA**

Learning Objectives:

The learning objectives of this course are as follows:

- This course offers an insight about the various types of human diseases.
- This course offers an insight about the various types of Farm Animal diseases
- The students will understand the concepts of pathogens and pathological basis of diseases including infectious diseases caused by viruses, prokaryotes, protozoans, helminthes, vector-borne and zoonotic diseases.
- Vector biology, medical importance and management of the medically important insects and Veterinary Insect Pests

Learning Outcomes

Upon completing this course, students will be able to:

- Identify and describe the importance of medical and veterinary pests: Recognize and describe the biology, ecology, and behavior of various pests, including insects, arachnids, and rodents.
- Understand the role of pests in disease transmission: Explain the role of pests in transmitting and maintaining diseases, and understand the impact of pest-borne diseases on human and animal health.
- Apply integrated pest management principles: Design and implement integrated pest management strategies that incorporate multiple control methods, including chemical, biological, physical, and cultural controls.

- Use surveillance data for pest management decision-making: Collect and analyze surveillance data to inform pest management decisions, and understand the importance of monitoring pest populations and activity.
- Select and apply appropriate pest control methods: Choose and apply effective pest control methods, including chemical, biological, physical, and cultural controls, and understand their advantages and limitations.
- Understand the importance of personal protective equipment (PPE) and other prevention methods: Recognize the importance of PPE and other prevention methods in preventing pest-borne diseases, and understand how to use them effectively.
- Communicate effectively about pest management: Communicate effectively with various stakeholders, including the public, healthcare professionals, and animal owners, about pest management strategies and risks.

Theory **30 h**

Unit-1: Introduction **4 h**

Definitive host, Intermediate host, Parasitism, Ecto- & Endoparasites of skin, Symbiosis, Commensalism, Reservoir, Zoonosis.

Unit- 2: Medically important insect pests **8 h**

Mosquitoes: Anopheles, Culex, Aedes. Rat Flea, Head and body louse, Bed bug, Sand fly Insect, Endoparasites (*Dermatobia hominis and Calliphoridae*)

Unit- 3: Transmission and control of various pathogens and insect vectors **12 h**

Plasmodium vivax, Trypanosoma gambiense; Wuchereria bancrofti, Dengue virus**.** Control of insect vectors of public health. Management of vector borne diseases by Integrated Vector Management.

Unit-4: Veterinary Insect Pests, their life cycle, transmission and control of diseases **6 h**

Flies, Mosquitoes, Ticks, Fleas, Lice and Mites

Practicals **60 hrs**

(Laboratory periods: 15 classes of 4 hours each)

1. Field collection of immature stages of mosquitoes and preparation of temporary slides.
2. Study of ~~few~~ available pathogens of arthropod-borne diseases. Malaria, Culex, Dengue
3. Study of different mosquitoes through photographs

4. Study of life history stages of medically important arthropods by using slides/ photographs: Flies, Ticks, Fleas, Lice and Mites
5. Visit any Vector borne disease lab or carry out a survey of breeding places of Vectors and make a report on your visit/ survey

Suggested Readings:

1. Mullen, Gary R. and Durden, Lance A. (2019). Medical and Veterinary Entomology. Elsevier ; 3rd Edition. ISBN 978-0-12-814043-7
2. Ramnik. Sood (2009) Medical Laboratory Technology Methods and Interpretations, 6th edition; Jaypee Brothers Medical Publishers, ISBN-13: 978-8184484496.
3. Robbins, Basic Pathology, 9th edition (2012), Kumar, Abbas, Fausto and Mitchell; Saunders Publication, ISBN-13: 978-1437717815

Additional Resources:

1. UGC INFONET / DU E-Resources & Sci Finder Web Version registration
2. Arora, D.R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications

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DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 11**

LOCUSTS AND THEIR MANAGEMENT

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practicals/ Practice		
Locusts and their Management **ALS ZOO DSE 11**	**4**	**2**	**Nil**	**2**	Appeared in Sem-VII	**NA**

Learning Objectives:

The learning objectives of this course are as follows:

- The course aims to apprise the students of locust as one of the most dangerous pests of agricultural crops.
- To focus on identification of locust, reasons of their swarming and migratory nature which gives immense economic loss leading to national emergency of food and fodder.
- To provide knowledge about the control, monitoring and management strategies of locust.

Learning Outcomes:

By studying this course, students will be able to:

- learn about the importance of locust as serious pest that cause damage to the agro-ecosystems affecting the economy.
- learn about the habit, habitat, behaviour, morphology and different phases of locust.
- learn about the biology of locust and various methods of its control.

Theory: 30 h

Unit 1: Introduction to Locusts 7 h

Introduction, historical background, locust plague and upsurges, Systematic position of locusts and grasshoppers; habitat, behaviour and morphology of locusts. Difference between locusts and grasshoppers.

Unit 2: Distribution, life cycle of Locusts in India **6 h**

Locusts in India, distribution, life cycle of different species: *Schistocerca gregaria, Patanga succincta, Locusta migratoria;* damage caused by them.

Unit 3: Breeding of Locusts **5 h**

Breeding seasons and breeding areas, swarming. Biological phases: solitary, transient and gregarious. Changes in their behavior, color and structure. Biotic theory of periodicity.

Unit 4: Locust management **12h**

National and international organizations - LWO, SALO, CALO, FAO, NLCC, IRLCO-CSA (International Red Locust Control Organization for Central and Southern Africa), swarm monitoring. Control methods- Mechanical and traditional, regulatory practices,Chemical methods: ULV Sprays, dusting, baits, IGRs; advantages and disadvantages of different chemical control methods, biological practices: biopesticides, predators, parasitoids; Integrated Pest Management; Plant quarantine. Socio-Economic importance: Impact on the health of fauna and humans; on agriculture.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. Comparative study of different species of locusts through specimens /photographs.
2. Study of mouthparts, wings and legs of locust through specimens /photographs.
3. Study of sexual dimorphism in locust through specimens/photographs.
4. Study the life stages of the locust through specimens/slides/photographs.
5. Study of different tools used in the management of locust.
6. Study of different host plants of locust.
7. Visit to different institutes/stations/laboratories (submit a Report on visit/current status of locusts in India).

Essential/recommended readings

1. Ritchie, J. M., &Dobson, H. (1995).*Desert Locust, control operations and their environmental impact*. NRI bulletin 67, Hopps the printers Ltd.
2. Atwal, A. S.; &Dhaliwal, G. S. (2015). *Agricultural pest South Asia and their management* (8th Ed.). Kalyani publishers.
3. Pradhan, S. (2016). *Agricultural Entomology and Pest Control*. ICAR publication.
4. Pandey & Kumari R. (2021) *Locust in Indian Agriculture*. Notion press India.

Suggested readings

1. Rachadi, Tahar (2010). *Locust control handbook*. CTA publication, AJ Wagningen, The

Netherlands.
2. Krall, S; Peveling, R & Diallo, D. Ba. (1997).*New strategies in Locust Control*. Pirahauser Basel springer.

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DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 12**

PATHOGENS OF INSECTS IN PEST MANAGEMENT

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practicals / Practice		
Pathogens of Insects in Pest Management **ALS ZOO DSE 12**	**4**	**2**	**Nil**	**2**	**Appeared in Sem-VII**	NA

Learning Objectives:

The learning objectives of this course are as follows:

- to provide knowledge about the basic pathogens infecting insects.
- To understand Epizootiology, symptomatology and etiology of diseases caused by various agents.
- To promote use of environmentally friendly pest Control

Learning Outcomes:

By studying this course, students will be able to:

- Describe the nature and diversity of pathogens infecting insects, including viruses, bacteria, fungi, protozoa, and nematodes.
- Identify and classify different insect pathogens based on their biology, morphology, and mode of action.
- Assess the potential of entomopathogens as biological control agents in sustainable pest management.
- Advocate the use of insect pathogens as alternatives to chemical pesticides in promoting environmentally friendly pest control:

Theory **30 h**

Unit 1: Introduction to Insect Pathogens **6 h**

History of insect pathology, Classification of Insect Pathogens, infection of insects by bacteria, fungi, viruses, protozoa, rickettsia , spiroplasma and nematodes.

Unit 2: Etiology of Diseases and Defense systems **10 h**

Epizootiology, symptomatology and etiology of diseases caused by the Insect Pathogens and the controlling factors. Defense mechanisms in insects against pathogens.

Unit 3: Control of Pests **10 h**

Exploitation of Bacteria (Bacillus thuringiensis) and Viruses (Nuclear Polyhedrosis Viruses) for control of pests: Management and mass production techniques.

Unit 4: Sustainable Pest Control **4 h**

Safety and registration of microbial pesticides. Role of insect pathogens in Sustainable Pest Control.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. Equipments used in insect laboratory.
2. Identification of different groups of insect pathogens and symptoms of infection.
3. To study symptomatology and etiology of diseases caused by bacteria, fungi, viruses, protozoa, rickettsia, spiroplasma and nematodes with the help of photographs.
4. Isolation, culturing and testing pathogenicity of different groups of pathogens.
5. Testing Koch's postulates. Estimation of pathogen load.
6. Extraction of pathogens from live organisms and soil.

Essential/recommended readings

1. Boucias DG & Pendland JC. 1998. Principles of Insect Pathology. Kluwer Academic Publisher, Norwel.
2. Nitesh Kumar Maru, Ashwani Kumar, and Sunil Zachariah. Insect pathology: Text Book and Practicals Manual. Scientific Publisher, New Delhi.
3. Steinhaus EA. 1984. Principles of Insect Pathology. Academic Press, London.

Suggested readings

1. Yoshinori Tanada and Harry K. Kaya. **Insect Pathology** Academic Press.London.
2. Burges HD & Hussey NW. (Eds). 1971. Microbial Control of Insects and Mites. Academic Press, London.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 13**
Insect Toxicology

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practicals/ Practice		
Toxicology of Pests **ALS ZOO DSE 13**	**4**	**2**	**nil**	**2**	**Appeared in Sem-VII**	NA

Learning Objectives:

Learning objectives of this course are as follows:

- To impart knowledge about the biological effects of toxic chemicals on insects.
- To emphasize on factors affecting toxicity of insecticides and synergistic substances which can be used to increase their efficacy.
- To enable students to understand the development of resistance in insects to insecticides.

Learning Outcomes:

By studying this course, students will be able to:

- learn about the principles of insecticide toxicity
- understand the safe use of toxic insecticides as well as treatments for insecticide poisoning.
- acquire Practicals skills of pest management in public buildings like termite proofing, rodent control.

Theory 30h

Unit 1. Introduction to Toxicology 4h

History of chemical control, Pesticides registration, Pesticide industries and markets.

Unit 2. Principles of Toxicology 10h

Evaluation of insecticide toxicity: LC50/ LD50, ED50, LT50 etc, Tolerance limits, ADI value, Bioaccumulation; Joint action of insecticides: synergism, potentiation, antagonism, Insecticide compatibility, selectivity and Phytotoxicity, Factors affecting toxicity of insecticides.

Unit 3. Pesticide metabolism **8 h**

Mode of entry of pesticides: I, F, W Insecticides and their metabolism - phase I and phase II pathways, Pest resistance to insecticides; Mechanisms and types of resistance; Diagnosis and treatment of insecticide poisoning, Health hazards: carcinogenic, mutagenic and teratogenic effects.

Unit 4. Pest Management in Residential and Public Places **8 h**

Principles and methods of pest management in residential places and public buildings, Insecticides for domestic use and their safety, Pre and post-construction termite proofing of buildings, Appliances for domestic pest control; Organic methods of domestic pest management.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. To calculate LD50/ED50/LT50 of an insecticide from data provided.
2. To study the equipment used for spraying and dusting of insecticide**s.**
3. Metabolism of insecticides in insects using TLC
4. Pesticide residues analysis of soil samples by soxhlet extraction method
5. Video Demonstration of Gas chromatography/ HPLC.
6 Project Report on visit to IARI, IPFT, Hindustan Insecticides Ltd., FCI complex, etc.

Suggested Readings:

1. Ishaaya, I., & Degheele, (Eds.). (1998). *Insecticides with Novel Modes of Action.* Narosa Publication. House.
2. Matsumura, F. (1985). *Toxicology of Insecticides*. Plenum Press.
3. Perry, A.S., Yamamoto, I., Ishaaya, I., &Perry, R. (1998). *Insecticides in Agriculture and Environment.* Narosa Publication. House.
4. Prakash, A., & Rao, J. (1997). *Botanical Pesticides in Agriculture.* Lewis Publication.

Additional Readings:

1. Greim, H., & Snyder, R. (ed)., (2018). *Toxicology and Risk Assessment: A Comprehensive Introduction.* John Wiley and Sons.
2. Whitford, F. (2002). *The Complete Book of Pesticide Management.* Wiley Interscience, John Wiley and Sons.
3. Chattopadhyay, S.B. (1985). *Principles and Procedures of Plant Protection.* Oxford & IBH.
4. Gupta, H. C. L. (1999). *Insecticides: Toxicology and Uses.* Agrotech. Publication.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 14**

Application of Biotechnology for Pest Management

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	**Credits**	**Credit distribution of the course**			**Eligibility criteria**	**Pre-requisite of the course (if any)**
		Lecture	**Tutorial**	**Practicals / Practice**		
Application of Biotechnology for Pests-Management **ALS ZOO DSE 14**	**2**	**1**	**Nil**	**1**	**Appeared in Sem-VII**	NA

Learning Objectives:

Learning objectives of this course are as follows:

- To provide knowledge about alternative measures to traditional pest management practices against insects.
- To learn about various tools and techniques of biotechnology used for controlling insect pests.

Learning Outcomes:

By studying this course, students will be able to:

- distinguish between various types of pests and the damage they cause to their host plants.
- acquire the skill to use important tools and techniques of biotechnology for management of pests.

Theory **30h**

Unit 1: Introduction to eukaryotic cell culture **4 h**

Introduction to eukaryotic cell culture; Historical background, Biology of animal cell and cell-cell interactions, good laboratory practices, Sterilization methods and techniques. Isolation of the tissue, Initiation of culture: Types of primary culture. Subculture and cell lines;

Unit 2: Media and Buffers **6 h**

Types of culture media, Physicochemical characteristics of medium-Osmolality, Temperature, Viscosity and Surface Tension. Importance of Serum and Serum-free media, Antibiotics and other supplements.

Unit 3: Advanced Cell culture techniques **15 h**

Principles of cryopreservation of cell lines. Methodology of production of chimeric DNA, I*n vitro* transfection of animal cells-chemical method, lipid mediated gene transfer (lipofection), Electroporation. Microbial contaminants (Bacteria, Yeast, Fungi, Mycoplasma and Virus) in cell line. Applications of Animal Cell Culture: Toxicology studies, Vaccine production, Gene therapy, Stem cell therapy, Production of recombinant proteins, Derived benefits from DNA barcode-based molecular taxonomy, Use of biotechnology for insect pest management

Unit 4: Challenges and Technologies for Pest management **5 h**

International project on barcode of life, Host–plant resistance: mechanism of resistance-antibiosis, antixenosis, tolerance, factors mediating resistance. Transgenic mosquito**,** Genetic control through sterile insect techniques.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. Packing and sterilization of glassware and plasticware for cell culture.
2. Preparation and sterilization of culture medium, buffers and solutions.
3. To study about cytotoxicity and cell viability.
4. Demonstration of Transfection in cell lines using Photographs/Videos.
5. Demonstration of working of the following instruments:

i) Laminar Flow Hood ii) Autoclave iii) Humidified CO_2 Incubator iv) pH Meter.

6. Project report on visit to animal cell culture labs

Essential/recommended readings

1. Freshney, R. IAN. (2021). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (8th Ed.).
2. Masters, John. R. W. (2000). Animal Cell Culture: A Practicals Approach (3rd Ed.).
3. Butler, M. (2003). Animal Cell Culture and Technology. (2nd Ed.).

Suggested readings

1. Davis, John. M. (2011). Animal Cell Culture: Essential Methods.
2. Bhatt, Sheelendra. M. (2011). Animal Cell Culture: Concept and Application.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

COURSES OFFERED BY DEPARTMENT OF CHEMISTRY

B Sc. (H) Chemistry

Undergraduate Programme of study

Semester-wise Distribution of Discipline-Specific Core (DSC) Courses

DISCIPLINE CORE COURSES –02 (4 Credits each)			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
VII	DSC-19	Advanced Chemistry -I	T=3 P=1
VIII	DSC-20	Advanced Chemistry-II	T=3 P=1

DISCIPLINE SPECIFIC ELECTIVE COURSES – (4 Credits each)			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
VII	DSE-14	Main Group Clusters-Basics and Applications	T=2 P=2
	DSE-15	Advanced Coordination Chemistry	T=2 P=2
	DSE-16	Advanced Stereochemistry	T=2 P=2
	DSE-17	Reactive Intermediates of Organic Chemistry	T=2 P=2
	DSE-18	Advanced Molecular Spectroscopy and Applications	T=2 P=2
	DSE-19	Interfaces, Macromolecules and Biophysical Chemistry	T=2 P=2
VIII	DSE-20	Transition Metal Clusters-Introduction & Applications	T=2 P=2
	DSE-21	Advanced Analytical Techniques for Inorganic Compounds	T=2 P=2
	DSE-22	Fundamentals of Natural Products	T=2 P=2
	DSE-23	Fundamentals of Medicinal Chemistry	T=2 P=2
	DSE-24	Interfacial Chemistry	T=2 P=2
	DSE-25	Fundamentals of Solid state & Materials chemistry	T=2 P=2

DISCIPLINE-SPECIFIC CORE COURSE - 19 (DSC-19)

Advanced Chemistry-I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical		
Advanced Chemistry-I (DSC-19)	**04**	**03**	—	**01**	--	--

Learning Objectives

- The course is designed to provide the fundamental understanding of the principles of operation and interpretation of spectra of inorganic and organic compounds for their structural characterization relevant to real-world applications. The students will acquire knowledge of solving structural problems based on UV-VIS, IR, ^{1}HNMR, ^{13}CNMR, and Mass spectral data.
- To introduce fundamental concepts of quantum mechanics, including vector spaces, operator algebra, angular momentum, spin, and the application of these concepts to atomic and molecular systems.
- To develop a quantitative understanding of Dirac notation, commutation relations, the Heisenberg Uncertainty Principle, and spin eigenfunctions.
- To provide a foundational understanding of molecular symmetry through symmetry elements, point groups, and character tables.
- To apply group theory to interpret spectroscopic data, derive selection rules, and understand molecular vibrations in infrared and Raman spectroscopy.

Learning Outcomes

The students will learn to:

1. To analyze and interpret experimental data collected of inorganic materials using different spectroscopic techniques
2. To be able to learn and analyze the theory and principle of mass spectroscopy, various ionization techniques involved and different types of detectors used and to implement the theory to interpret the mass spectra.

- Understanding spectroscopic techniques and their application in the structural elucidation of organic molecules.

- Understand the basic concepts and quantitative aspects of chemical phenomena, which require knowledge of both quantum chemistry and mathematics.
- Apply relevant mathematical methods essential for solving problems in quantum chemistry.
- Interpret symmetry elements and operations in molecules using the principles of group theory.
- Predict spectroscopic transitions using symmetry considerations and selection rules.
- Demonstrate an integrated understanding of how quantum chemistry and group theory together contribute to the interpretation of molecular spectroscopy.

SYLLABUS OF DSC 19

Unit-1: Spectroscopy for Inorganic Materials & Basics of Mass Spectrometry (Hours: 15)

ATR-IR, and Solid state or multinuclear NMR Spectroscopy of inorganic materials: Basics and applications of IR spectra in inorganic materials, total internal reflectance of inorganic materials, diffuse reflectance spectroscopy (DRS), Kubelka-Munk equation. ^{1}H, ^{13}C NMR spectra of metal complexes, dipolar and contact shifts. Basics of Magic angle spinning NMR spectroscopy (MAS NMR).Example of solid-state NMR with ^{10}B, ^{11}B, ^{17}O, ^{19}F, ^{27}Al, ^{29}Si, ^{31}P nuclei.

Mass spectrometry: Experimental arrangements, Ion sources, Mass analysers and detectors, Data analysis, Molecular ions, Fragmentation, Ion reactions, combined mass spectrometry methods, Tandem mass spectrometry (MS/MS), Chromatography-coupled mass spectrometry.

Unit-2: Organic Spectroscopy (Hours: 15)

Recapitulation of the Spectroscopic Techniques (UV- VIS, IR, and ^{1}HNMR)

13-CNMR and 2D NMR Spectroscopy: Resolution and multiplicity of ^{13}C NMR, ^{1}H-decoupling, noise decoupling, broadband decoupling; Deuterium, fluorine, and phosphorus coupling; NOE signal enhancement, off-resonance, proton decoupling, Structural applications of CMR. DEPT and general introduction about 2D NMR.

MASS: Theory, Fourier transform mass spectrometry instrumentation (FTMS); Unit mass and molecular ions; Important terms singly, doubly/multiple charged ions, metastable peak, base peak, isotopic mass peaks, relative intensity; Recognition of M^{+} ion peak; Nitrogen rule; Rule of 13; Ionization methods (EI and ESI). General fragmentation rules: McLafferty rearrangement, ortho effect.

ESR: Basic Principles and applications for organic Compounds

Structure elucidation of organic compounds using UV, IR, NMR, and Mass Spectra.

Unit 3: Quantum Chemistry (Hours: 7)

Introduction to vector spaces (Particle in 1-D box), Dirac's Bra-ket notation, Turn-over rule, Commutation of operators Heisenberg's Uncertainty principle (derivation and physical significance), Angular momentum: definitions, creation and annihilation operators; spherical harmonics, Spin operators and eigenfunctions; two-electron systems (qualitative).

Unit 4: Molecular Symmetry (Hours: 8)

Symmetry elements and operations; Point groups (BF_3, NH_3, H_2O), Classes, reducible and irreducible representations, Similarity transformation, Character table & Great Orthogonality Theorem (without proof)), Transition moment integrals, Selection Rules, IR and Raman activity: Group theoretical approach, examples predicting vibrational activity using character tables.

Practical component

1. Synthesis of substituted ferrocene and its mass-spectrometry analysis.
2. Synthesis of substituted Metal acetylacetonate and its mass-spectrometry analysis.
3. ATR-IR, NMR analysis of metal complexes acetylacetonate complexes of Iron, Manganese and Copper.
4. Diels-Alder reaction between maleic anhydride and anthracene and identification of the product using IR and NMR Spectroscopy.
5. Knoevenagel condensation between aromatic aldehydes (benzaldehyde/*p*-nitrobenzaldehyde) and active methylene compounds (malononitrile/ethylcyanoacetate/diethylmalonate) and identification of the product using IR and NMR Spectroscopy.
6. Differentiate between maleic and fumaric acid solutions by UV spectroscopy.
7. Determination of the effect of pH on absorbance maximum (UV-Vis spectra) of the organic compounds. (Aniline, Benzoic acid, phenol etc.)
8. Demonstration of the separation of the mixture of *p*-nitrophenol and *o*-nitrophenol by column chromatography and their characterization by melting point and spectroscopic techniques.
9. Determine the specific reaction rate of the potassium persulphate-iodide reaction by the Initial Rate Method.
10. Titrate a moderately strong acid (Salicylic/Mandelic acid) by the (a) salt-line method (b) double alkali method.
11. Titrate a tribasic acid (phosphoric acid) against NaOH potentiometrically.
12. Plotting of atomic orbitals (Spherical Harmonics S(θ) versus θ using polar graph paper. Student will be provided with the *p*-, *d*- and *f*- functions.
13. Plotting of $\psi_n(x)$, and $|\psi_n(x)|^2$ for wavefunctions of 1D harmonic oscillator in different energy levels within the domain of x, $-\infty < x < +\infty$.
14. Calculate the bond length of conjugated dye molecules (i.e., cyanine/β-carotene) using particle in 1D box model.
15. Simulated IR Spectra: assign bands using symmetry and selection rules.

(Spectra to be provided wherever required and may be obtained using the following link: https://webbook.nist.gov/chemistry

Note: A minimum of 4 to be done from 9-15

Recommended References and Textbooks (For Theory)

1. Banwell, C.N.; McCash, E.M. (2006), Fundamentals of Molecular Spectroscopy, Tata McGraw- Hill.
2. Springsteen, A. (1998), Reflectance Spectroscopy: an overview of classification and techniques. In Applied Spectroscopy; Workman, J., Springsteen, A., Eds.; Academic Press 193–224. DOI: 10.1016/B978-012764070-9/50008-1.
3. Fitzgerald, J.J. and DePaul, S. M. (1999), Solid-State NMR Spectroscopy of Inorganic Materials: An Overview, 2-133, DOI: 10.1021/bk-1999-0717.ch001.
4. Brevard, C. and Granger, P. Handbook of high resolution multinuclear NMR, A Wiley publisher, 1981 and Brevard, C. The multinuclear approach to NMR spectroscopy, Springer Netherlands, 1983.
5. Nielsen, NielsChr, Strassø, Lasse A, and Nielsen, Anders B. Solid state NMR, Springer-Verlag Berlin Heidelberg, 2012.
6. D. W. Rankin, N. Mitzel, and C. Morrison, Structural methods in molecular inorganic chemistry. John Wiley & Sons, 2013.
7. E. A. V. Ebsworth, D. W. Rankin, and S. Cradock, Structural methods in inorganic chemistry. Blackwell Scientific Publications, Oxford, 1987.
8. William Henderson and J. Scott McIndoe, Mass Spectrometry of Inorganic, Coordination and Organometallic Compounds: Tools – Techniques – Tips, John Wiley and Sons, Ltd, 2005, ISBN 0-470-85015-9
9. J.M. Modern spectroscopy, Hollas, 4th edition John Wiley and sons Ltd., 2004.
10. Kemp, W. Organic Spectroscopy 3rd Ed., W. H. Freeman & Co. (1991).
11. Silverstein, R. M., Bassler, G. C. & Morrill, T. C. Spectroscopic Identification of Organic Compounds. John Wiley & Sons (1981).
12. Pavia, D. L.; Lampmann, G. M.; Kriz, G. S.; Vyvyan, J. R. Introduction to Spectroscopy. Cengage Learning (2014).
13. Organic Structures from spectra; L. D. Field, S. Sternhell and J R Kalman, John Wiley & Sons Ltd., 2007.
14. Lowe, J. P. & Peterson, K. Quantum Chemistry Academic Press (2005).
15. McQuarrie, D. A. Quantum Chemistry Viva Books Pvt Ltd.: New Delhi (2003).
16. Mortimer, R. G. Mathematics for Physical Chemistry 2nd Ed. Elsevier (2005).
17. Pilar F. L. Elementary Quantum Chemistry 2nd Ed., Dover Publication Inc.: N.Y. (2001).
18. Atkins, P. W. &Friedman, R.S.,Molecular Quantum Mechanics 3rd Ed., Oxford University Press (2004).
19. Kakkar R., *Atomic and Molecular Spectroscopy*, Cambridge University Press, (2015).
20. Levine, I. L. Quantum Chemistry 5th Ed., Prentice-Hall Inc.: New Jersey (2000).
21. Bakhshi, A. K., and Thakral P., Quantum Chemistry Simplified, Vidyavani Foundation, New Delhi, ISBN: 9788196225107 (2023).
22. Cotton, F. A. Chemical Applications of Group Theory Wiley Interscience: N.Y (1990).
23. Bishop, D. M. Group Theory and Chemistry, Clarendon Press: Oxford, U.K. (1973)

Supplementary readings

1 Quantum Chemistry and Group Theory, MCH-018, IGNOU Self Learning Material, egyankosh, Indira Gandhi National Open University (2025)
https://egyankosh.ac.in/handle/123456789/107771

2 Silbey, R. J., Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed. Wiley (2004)

3 Rakshit, S. C.; Atomic & Molecular Symmetry Groups and Chemistry, CRC Press, Taylor and Francis Group.

Recommended Reference and Textbooks (For Practical)

1. Vogel, A. I. (**2012**). Quantitative Organic Analysis, Part 3, Pearson Education.

2. Mann, F. G., Saunders, B.C. (**2009**), Practical Organic Chemistry, Pearson Education.

3. Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (**2012**), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.

4. Ahluwalia, V.K., Dhingra, S. (**2004**), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

5 Morrill, L. A., Kammeyer, J. K., & Garg, N. K. (**2017**). Spectroscopy 101: A practical introduction to spectroscopy and analysis for undergraduate organic chemistry laboratories.*J. Chem. Educ.*94(10), 1584-1586.

6 McQuarrie, D. A. Quantum Chemistry Viva Books Pvt Ltd.: New Delhi (2003).

7 Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.

8 Kapoor, K.L., A Textbook of Physical Chemistry, Vol. IV, fifth Edition, McGraw Hill Education.

9 Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).

DISCIPLINE-SPECIFIC CORE COURSE - 20 (DSC-20)

Advanced Chemistry-II

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical		
Advanced Chemistry-II (DSC-20)	**04**	**03**	—	**01**	--	--

Learning Objective:

- This course delves into the fascinating intersection of bio-inorganic metals and their crucial roles in living systems. The detailed investigation of bio-inorganic chemistry of essential elements towards biomedical applications. To facilitate chemical transformations by providing the necessary conditions and catalysis.
- To provide a brief foundational understanding of the core principles of classical and quantum statistical mechanics.
- To explore the connection between macroscopic thermodynamics and microscopic quantum mechanics using various statistical ensembles.
- To introduce the Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics with a brief, qualitative understanding and focus on their applications.
- To enable students to apply statistical concepts in key areas such as the standard model for macromolecular systems, chemical kinetics, and chemical equilibrium.

Learning outcomes

By the end of the course, students will be able to:

- Understand the fundamental principles of statistical mechanics, including how they link microscopic behaviour to macroscopic properties of systems.
- Apply the Boltzmann distribution, Bose-Einstein statistics, and Fermi-Dirac statistics to various physical and chemical systems.
- Utilize partition functions to analyze and solve problems related to the thermodynamic properties of systems.
- Explore the application of statistical mechanics to key areas such as chemical kinetics, chemical equilibrium, and random walk models in macromolecular systems.
- Understand the advance application of bio-inorganic metals.

- Explore the structure and properties of inorganic materials used in biomedical applications.
- Investigate the biocompatibility and bioactivity of inorganic biomaterials.
- Discuss current research and future directions of bio-inorganic chemistry.
- Understand various reducing agents, oxidizing agents, and their applications in organic synthesis.
- Understand the conversion of specific functional groups without affecting others and maximize yields and selectivity for the desired products.

SYLLABUS OF DSC 20

Unit 1: Metals in Biological System **(Hours: 5)**

Biominerals and biomineralization, Detailed study of biocatalyst in the metabolism of Hydrogen, carbon, and sulfur, Biological actions of manganese, cobalt and nickel ions, Metal ions in brain and medicine, Homeostasis of Metals, Potassium-Dependent Molecules, Inorganic Nanoparticles in Wound Healing and Drug Delivery.

Unit 2: Inorganic Materials for Biomedical Applications **(Hours: 10)**

Natural Bone Structure and Composition, Calcium Phosphate Ceramics (e.g., hydroxyapatite, tricalcium phosphate), Metal Implants (e.g., titanium, stainless steel), Natural Tooth Structure and Composition (enamel, dentin), Dental Ceramics (e.g., zirconia, alumina), 3D Bioprinting.

Unit 3: *Reagents in Organic Synthesis* (**15 Hours**)

Triacetoxyborohydride, Lead Acetate, Phenyliodine (III) diacetate (PIDA), DCC, Tamao-Fleming Oxidation; Dimethyldioxirane (DMDO) Oxidation; DMSO (Barton modification &Swern Oxidation); Oxidation of organic compounds using thallium nitrate, selenium dioxide, phase transfer catalyst, crown ethers, $KMnO_4$, PCC, OsO_4, CrO_3, $K_2Cr_2O_7$**.**
Synthesis and applications of BuLi, Grignard, organoaluminium, and organozinc reagents**.**
Applications of hydroboration (reductions, oxidations, and carbonylation): Diborane, 9-BBN**.**

Unit 4: Statistical Thermodynamics and its Applications **(15 Hours)**

Microstates, Configurations, coin tosses, rolling of dices, spin systems (in the absence of magnetic field),Thermodynamic probability, Stirling's approximation, Concepts of ensembles (Microcanonical and Canonical), Characteristic thermodynamic functions, Translational partition function (quantitative), Rotational and vibrational partition functions (qualitative), Maxwell-Boltzmann distribution, Bose-Einstein, and Fermi-Dirac Statistics (Qualitative).
Conventional transition state theory derived from partition functions, Equilibrium constants in terms of partition function: gas-phase reactions (K_p), isotope effects.
1-D random walk model, Number and weight average molecular weight, polydispersity index.

Practical Component

Identification of the product based on Melting point and spectroscopic techniques (IR, ^{1}HNMR, and ^{13}C NMR spectroscopy, data to be provided).

1. Synthesis and characterization of calcium phosphate ceramics spectrophotometrically /any other method.
2. Analyzing the composition of Bio materials(Stainless steel, hydroxyapatite)
3. Fabrication of a simple Bio-hydrogel (Polyvinyl alcoholhydrogel, polysaccharide hydrogel, cellulose,starch)
4. Preparation of Zirconia (ZrO_2).
5. Preparation and characterisation of transition metal complexes of riboflavin using commercially available Vitamin B2 supplements.
6. Synthesis of 1,2,3,4-tetrahydrocarbazole from cyclohexanone.
7. Reduction of *p*-nitrobenzaldehyde using suitable reagents. ($NaBH_4$/Sn-HCl)
8. Synthesis of 2,3-diphenylquinoxaline from benzil and *ortho*-phenylenediamine.
9. Oxidation of Aryl Aldehydes into Ester by I_2 and Alcohols.
10. Study the kinetics of the iodination of acetone in the presence of acid by the *Initial Rate Method*.
11. Titrate a tribasic acid (phosphoric acid) against NaOH and $Ba(OH)_2$ conductometrically.
12. Find the composition of the zinc ferrocyanide complex by potentiometric titration.
13. Statistical Treatment of Error Analysis (Null Hypothesis, T-test, F-test, Q-test (criteria for reject of hypothesis) Statistical analysis of laboratory data.
14. Determination of standard deviation, mean and maximum absolute errors, root-mean-square deviation (error) and Correlation coefficient of linear straight-line plot.

Recommended References and Textbooks (For Theory)

1. Bio-coordination Chemistry, D E Fenton, OUP, 2002
2. Principles of Bioinorganic Chemistry, S J Lippard and, J M Berg, USB, California, 1994
3. Biological Inorganic Chemistry, R.R Crichton, Elsevier, 2012
4. Y. Bar-Cohen, Biomimetics: Biologically Inspired Technologies, Taylor & Francis CRC Press, Boca Raton, FL, 2006.
5. R.L. Reis, S. Weiner, Learning from Nature How to Design New Implantable Biomaterials, Kluwer Academic Publishers, New York, 2005.
6. P. Behrens, E. Bäuerlein, Handbook of Biomineralization: Biomimetic and Bioinspired Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2007.
7. H. Lowenstam, S. Weiner, On Biomineralization, Oxford University Press, New York, 1989.
8. S. Mann, Biomineralization: Principles and Concepts in Bioinorganic Materials Chemistry, Oxford University Press, Oxford, New York, 2001.
9. E. Bäuerlein, Biomineralization: Progress in Biology, Molecular Biology and Application, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004.

10. E. Bäuerlein, Handbook of Biomineralization: Biological Aspects and Structure Formation, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2007.
11 F.E. Round, R.M. Crawford, D.G. Mann, The Diatoms: Biology and Morphology of the Genera, Cambridge University Press, Cambridge, 1990.
12 Carruthers, W. Modern Methods of Organic Synthesis. Cambridge University Press (**1996**).
13 Carey, F.A. & Sundberg, R. J. Advanced Organic Chemistry, Parts A & B, Plenum: U.S. (**2004)**.
14 Jonathan Clayden, Nick Greeves, Stuart Warren. Organic Chemistry. Oxford. (**2000**).
15 McQuarrie, D. A. *Statistical Mechanics,* Viva Books Pvt. Ltd.: New Delhi (2003).
16 L. D. Landau and E. M. Lifshitz, Statistical Mechanics, Part I, Butterworth-Heinemann, 3rd ed. (2005).
17 Bagchi B. *Statistical Mechanics for Chemistry and Material Science,* CRC Press (2018).
18 Laidler, K. J. *Chemical Kinetics* 3rd Ed., Benjamin Cummings (1997).
19 Billmeyer, F. W. *Textbook of Polymer Science* 3rd Ed. Wiley-Interscience: New York (1984).
20 Pathria, R.K.; and Beale, P. D.;Statistical Mechanics, Fourth Edition, Elsevier, Academic press.
21 Huang, K., Statistical Mechanics, 2nd Ed., John Wley& Sons, New York (2000)

Recommended Reference and Textbooks (For Practical's)

1. Ahluwalia, V. K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
2. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
3. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
4. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi.
5. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
6. McQuarrie, D. A. & Simon, J. D. *Physical Chemistry: A Molecular Approach* 3rd Ed., Univ. Science Books (2001).
7. Skoog, D. A.; Holler, F. J.; Crouch, S. R. Principles of Instrumental Analysis, Brooks/Cole Pub Co; 7th edition (1 January 2017).
8. Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R. Fundamentals of Analytical Chemistry, Publisher: Holt, Rinehart & Winston of Canada Ltd; International 2 Revised ed edition (1 February 1988).

Semester -VII

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 14 (DSE-14)

Main Group Clusters-Basic and Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Main Group Clusters-Basics and Applications (DSE-14)	**04**	**02**	**--**	**02**	**__**	**--**

Learning Objectives:
To introduce the basic concepts of clusters.To gather a good understanding of the chemistry and various aspects of main group cluster compounds with respect to synthesis, structure and properties.

Learning Outcomes
On completion of the course, the students will be able to:

1. Ensures the students understand the concepts and the properties of clusters.
2. Acquire knowledge of cluster compounds and explain structure-property, electron counts, and surface analogies of cluster compounds.
3. Identify the structure and bonding aspects of main group clusters.
4. Identify the different types of main group cluster reactions and apply the above concepts to explain reactivity of the clusters.

SYLLABUS OF DSE 14

Unit 1: (Hours: 7)
Introduction to molecular clusters - Clusters in elemental states, cluster classification, skeletal electron (Elm) counting.
Unit 2: (Hours: 8)
Main-group clusters: Geometric and electronic structure, three-, four- and higher connect clusters, the *closo-, nido-, arachno-hypho-, klado-,*borane structural paradigm

Unit 3: (Hours:8)

Wade-Mingos and Jemmis electron counting rules, Lipscomb topological diagrams, clusters with nuclearity 4-12 and beyond 12. Structure

Unit 4: (Hours 7)

Synthesis and reactivity. Heteroboranes, boron-carbides and metal-borides.Illustrative examples from recent literature.

Keywords: Clusters, skeletal electron count, boranes, synthesis, reactivity.

Practical Component

1. Determination of Boron colorimetrically.
2. Preparation of borax/ boric acid.
3. Synthesis of zinc borate from zinc oxide and boric acid and their analysis using various instrumentation techniques: IR, UV, TGA, and DSC. Thermal decomposition of borax and its structural characteristics using XRD, FTIR.
4. Qualitative analysis of cobalt, nickel, copper etc. using borax (borax bead test).
5. Other new novel synthesis reported in literature from time to time
6. Syntheses and characterisation of zinc(II)acetylacetonate and tin(II)acetylacetonate complexes

Recommended References and Textbooks

1. M. P. Mingos and D. J. Wales; Introduction to Cluster Chemistry, Prentice Hall, 1990.
2. N. Greenwood and E. A. Earnshaw; Chemistry of elements, Second Edition, Butterworth-Heinemann, 1997.
3. P. Fehlner, J. F. Halet and J-Y. Saillard; Molecular Clusters: A Bridge to solid-state Chemistry, Cambridge University press, 2007.
4. B. D. Gupta and A. J. Elias; Basic Organometallic Chemistry: Concepts, Synthesis, and Applications, Universities Press (India), 2010.
5. M. P. Mingos, Essential Trends in Inorganic Chemistry, Oxford, University Press, 1998.
6. C. E. Housecroft, Metal-Metal Bonded Carbonyl Dimers and Clusters, Oxford Chemistry Primers (44), Oxford, University Press, 1996.

References

1. F. Holleman and E. Wifrg, Inorganic Chemistry, Academic Press, New York, 1995.
2. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley & Sons, Inc, New York, 1999.
3. G. Wulfsberg, Inorganic Chemistry, Viva Books Pvt Ltd, New Delhi, 2001.
4. B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley & Sons, Inc, New York, 2001.
5. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Shriver & Atkins Inorganic Chemistry, 4th Edn, Oxford, 2006.

6. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorgnic Chemistry: Principles of Structures and Reactivity, 4th Edn, Pearson, New Delhi, 2006.
7. R. Xu, W. Pang and Q. Huo (Eds), Modern Inorganic Synthetic Chemistry, Elsevier, New York, 2011.
8. G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rd Edn, Pearson, New Delhi, 2009.
9. J. R. Anderson and M. Boudart (Eds), Catalysis: Science and Technology, Springer, London, 2012.
10. P. Powell, Principles of Organometallic Chemistry, 2nd Edn, Chapman and Hall, London, 1988.
11. G. O. Spessard and G. L. Miessler, Organometallic Chemistry, International 2nd Edn, Oxford University Press, Oxford, 2010.
12. D. F. Shriver, H. D. Kaesz and R. D. Adams (Eds), The Chemistry of Metal Cluster Complexes, VCH, New York, 1990.
13. K. J. Klabunde, Free Atoms, Clusters and Nanoscale Particles, Academic Press, New York, 1994.
14. D. M. P. Mingos (Ed.), Structural and Electronic Paradigms in Cluster Chemistry, Springer, Berlin, 1997.
15. P. Braunstein, L. A. Oro and P. R. Raithby (Eds), Metal Clusters in Chemistry, Wiley-VCH, Weinheim, 1999.
16. M. Driess and H. Noth (Eds), Molecular Clusters of the Main Group Elements, Wiley-VCH, Weinheim, 2004.
17. C. E. Housecraft and A. G. Sharpe, Inorganic Chemistry, 3rd Edn, Pearson Education Ltd, Essex, England, 2008.
18. F. Wells, Structural Inorganic Chemistry, 5th Edn, Oxford University Press, Oxford, 1984.

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 15 (DSE-15)

Advanced Coordination Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Coordination Chemistry (DSE-15)	04	02	--	02	__	--

Learning Objectives:

- To introduce the basic concepts of coordination polymers and porous and cavity containing structures.
- To gather a good understanding of the chemistry, principles, design and synthesis of coordination polymers like metal-organic frameworks, coordination clustersalong with exploring their structures, properties and applications.

Learning Outcomes:

On completion of the course, the students will be able to:

- Have a strong foundation in understanding the basic concepts and properties of coordination polymers and porous and cavity containing systems.
- Gain an understanding of the different types of structures (single metal-noded, metal cluster-noded, pillared layer nets) of coordination polymers.
- Acquire knowledge on synthesis methods and how reaction conditions in synthesis can be used to design targeted coordination polymers.
- Acquire knowledge on the different types of structures of coordination polymers, e.g. MOFs, coordination clusters, etc and applications in catalysis and hydrogen storage.
- Learn about the design and morphology of self-assembling coordination compounds using suitable examples.

SYLLABUS OF DSE 15

Unit 1: (7 Hours)

Coordination polymers, assembly, single metal-noded nets, metal cluster-noded nets, pillared layer nets, and structural modulation by reaction conditions, including in situ metal/ligand reactions.

Unit 2: (7 Hours)

Coordination Polymers: Metal-Organic Frameworks and Other Terminology , 0D Coordination Clusters , 1D, 2D and 3D Structures

Unit 3: (8 Hours)

Magnetism , Negative Thermal Expansion , Interpenetrated Structures , Porous and Cavity-Containing Structures, Catalysis by MOFs , Hydrogen Storage by MOFs

Unit 4: (8 Hours)

Self-Assembling Coordination Compounds: Design and Notation, Supramolecular Cube, Molecular Squares and Boxes, Self-Assembly of Metal Arrays

Keywords:
Coordination polymers, metal-organic frameworks, self-assembly, catalysis, hydrogen storage

Practical Component:

1. Preparation of zeolite A and removal of Mg and Ca ions from water samples quantitatively using prepared zeolite A.
2. Estimation of MnO_2 in pyrolusite.
3. Preparation and characterization of following the following complexes/organometallic compound including their structural elucidation by the available physical methods. (Element analysis, molecular weight determination, conductance and magnetic measurement and special studies):
    - Synthesizing a nickel-citric acid coordination polymer using nickel nitrate, citric acid, and dimethylformamide (DMF) under solvothermal conditions.
    - Synthesizing Cu(II) coordination Polymers with 4,4-bipyridine.
    - Synthesis of *cis* and *trans* isomers of bis(glycinato) copper(II) monohydratye.
    - Synthesis of Cu acetate complex
4. Solid State synthesis-
    - Preparation of oxides and mixed oxides (Mn_2O_3, NiO, Cu_2O, Fe_3O_4, $ZnFe_2O_4$, $ZnMn_2O_4$, $CuMn_2O_4$ and $NiFe_2O_4$).
    - Preparation of Silica and Alumina by sol-Gel technique.
5. To study the electrical conductivity of ferrites, Magnetites, doped oxides and pure samples and determine band gap.

Recommended References and Textbooks

1. Synthesis and Characterization of Inorganic Compounds, W. L. Jolly, Prentice Hall.
2. Inorganic Experiments, J. DerckWoollins, VCH.
3. Practical Inorganic Chemistry, G. Marrand, B. W. Rockett, Van Nostrand.
4. A Text Book of Quantitative Inorganic Analysis, A. I.Vogel, Longoman.
5. EDTA Titrations. F. Laschka
6. Instrumental Methods of Analysis, Willard, Merit and Dean (CBS, Delhi).
7. Inorganic Synthesis, Jolly
8. Instrumental Methods of Chemical Analysis, YelriLalikov
9. Fundamental of Analytical Chemistry, Skoog D.A. and West D.M Holt Rinehart and Winston Inc.
10. Experimental Inorganic Chemistry, W. G. Palmer, Cambridge.
11. Solid state Chemistry, N. B. Hanney
12. Introduction to Thermal Analysis, Techniques and Applications, M.E.Brown, Springer
13. Preparation and Properties of solid state Materials, Wilcox, Vol.IandII, Dekker
14. The Structure and Properties of Materials Vol.IV, JohnWulff, Wiley Eastern.

References:

1. S.R. Batten, S.M. Neville, D.R. Turner, Coordination Polymers: Design, Analysis and Application, the Royal Society of Chemistry, Cambridge, UK, 2009.
   a. A.F. Wells, Three-Dimensional Nets and Polyhedra, Wiley-Interscience, New York, 1977.
   b. A.F. Wells, Further Studies of Three-dimensional Nets, ACA Monograph No.8, American Crystallographic Association, Knoxville, TN, 1979.
   c. A. F. Wells, Structural Inorganic Chemistry, fifteenth ed., Oxford University Press, Oxford, 1984.
2. J. Weitkamp, L. Puppe, Catalysis and Zeolites: Fundamentals and Applications, Springer, 1999.
3. D.W. Breck, Zeolite Molecular Sieves: Structure, Chemistry, and Use, Wiley, New York, 1973.
4. J.W. Steed, J. L. Atwood, Supramolecular Chemistry Chapters 9 and 10. pp. 561-583 and 620-637, John Wiley & Sons Ltd, Second Edition (2e, 2009) ISBN: 9781119582519
5. R.M. Barrer, Hydrothermal Chemistry of Zeolites, Academic Press, London, 1982.
6. J. Cejka, H. van Bekkum, A. Corma, et al., Introduction to Zeolite Molecular Sieves third ed. (Studies in Surface Science and Catalysis, Vol. 168), Elsevier, 2007.
7. S.M. Auerbach, K.A. Carrado, P.K. Dutta, Handbook of Zeolite Science and Technology, CRC, 2003.
8. C.J. Brinker, G.W. Scherer, Sol-Gel Science, Academic Press, New York, 1990.
9. R. Szostak, Molecular Sieves: Principles of Synthesis and Identification, Blackie Academic & Professional, London, 1998.

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 16 (DSE-16)

Advanced Stereochemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Stereochemistry (DSE-16)	04	02	--	02	__	--

Learning Objectives:

To provide a comprehensive understanding of molecular symmetry, isomerism, and chirality, including their applications in organic reactions.

***Learning Outcomes**:*

1. Students will be expected to gain knowledge of the basic concept of chirality in molecules due to their spatial arrangement of atoms that leads to chiroptical properties.

2. The three-dimensional arrangement of atoms in a molecule can lead to distinct physical and chemical properties, particularly for stereoisomers. Understanding stereochemistry is crucial for designing effective drugs, predicting reaction outcomes, and developing new materials.

3. Stereochemistry significantly impacts drug action, biological processes, and chemical reactions, influencing factors like drug efficacy, selectivity, and even the rate of chemical reactions.

SYLLABUS OF DSE 16

Unit 1: (**Hours:15**)

Stereoisomerism: Chiral (stereogenic) centre, principle of axial and planar chirality; Stereochemistry and configurations of biphenyls (atropisomerism), bridged biphenyls, ansa compounds and cyclophanes, allenes, spiranes, alkylidine cycloalkanes, adamantanes, catenanes and helicity.

Unit 2: (**Hours: 5**)

Topicity and prostereoisomerism: Topicity of ligands and faces and their nomenclature; Stereogenicity, chirogenicity, and pseudoasymmetry, stereogenic and prochiral centres.

Unit 3: **(Hours: 5)**

Cyclostereoisomerism: Configurations, conformations and stability of cyclohexanes (di-, and tri-substituted), cyclohexenes, cyclohexanones, decalin.

Unit 4: **(Hours:5)**

Asymmetric induction: Cram's, Prelog's, and Felkin-Ahn model. Applications of ORD and CD to Stereochemical Problems

Practical Component

(Any 10 practicals may be done depending upon the availability of resources.)

1. E/Z and Cis-Trans Isomerism of 2,3-dimethyl-2-butene by ball and stick models
2. Identification of ChiralCentres and Diastereomers by ball and stick models
3. Bromination of cis and trans stilbene
4. Addition of Bromine to trans-Cinnamic Acid
5. Photoinduced isomerization of *cis*-Stilbene to *trans*-Stilbene and *vice versa*
6. Photocatalytic/ thermal isomerization of maleic acid to fumaric acid.[3]
7. Preparation of stilbene dibromide by bromination of *trans*-stilbene.
8. Determination of optical rotation of sucrose, glucose, and fructose using polarimetry and determiningtheir concentration.
9. Two-step synthesis of acetonide from benzil and analysis of its stereochemistry using NMR and IR spectroscopy
10. Determination of specific rotation of(R)-limonene and (S)-limonene using Polarimeter.
11. Preparation of hydroxybenzoin by pinacol coupling reaction: Investigating the Diastereoselectivity of Benzaldehyde Pinacol Coupling Mediated by Al-KOH in Aqueous Media: Affording *meso*- and dl-Hydrobenzoin.[4]
12. Proline-catalyzed aldol reaction of cyclohexanone with nitro-substituted benzaldehydes.[5]

Recommended Reference and Textbooks: (For Theory)

1. Eliel, E. L. (2000), Stereochemistry of Carbon Compounds, Tata McGraw-Hill.

2. Nasipuri, D.(2018), Stereochemistry of Organic Compounds: Principles and Applications, 4th Edition, New Age International.

For Practical

1 Microscale Organic Laboratory (Multistep and Multiscale Syntheses). By Dana W. Mayo, Ronald M. Pike, David C. Forbes.**2011.**

2 Green Organic Chemistry: Strategies, Tools, and Laboratory Experiments, Kenneth M. Doxsee, James E. Hutchison. Thomson-Brooks/Cole, **2004.**

3 The photochemical isomerization of maleic to fumaric acid: an undergraduate organic chemistry experiment. Albert J. Castro, Suzanne R. Ellenberger, and James P. Sluka. *J. Chem. Edu.***1983**,*60* (6), 521 (DOI: 10.1021/ed060p52).

4 Using [1]H NMR Spectroscopy to Investigate the Diastereoselectivity of Benzaldehyde Pinacol Coupling Mediated by Al-KOH in Aqueous Media: An Undergraduate Lab Experiment Involving a Green Carbon–Carbon Bond-Forming Reaction Affording *meso-* and dl-Hydrobenzoins. Shahrokh Saba**;** Isabella Fante; James A. Cordero Jr.*J. Chem. Educ.* 2025, 102, 2, 847–851) doi.org/10.1021/acs.jchemed.4c01379
5 Proline-catalyzed asymmetric reactions. List, Benjamin. *Tetrahedron*. **2002**, 58 (28): 5573–5590. doi:10.1016/S0040-4020(02)00516-1

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 17 (DSE-17)

Reactive Intermediates of Organic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reactive Intermediates of Organic Chemistry (DSE-17)	04	02	--	02	__	--

Learning *Objectives:*
To learn and understand the involvement of intermediates, their role in reaction mechanisms, to predict their behaviour, and to apply this knowledge to organic synthesis. Also, to learn and understand the orbital interactions (Woodward-Hoffmann rules) in concerted reactions.

Learning Outcomes

At the completion of this course, the students should be able to:

i. Understand the structure-reactivity pattern of reactive intermediates involved in organic reactions.

ii Write the mechanism of organic reactions involving reactive intermediates and apply these reactions in organic synthesis

SYLLABUS OF DSE 17

Unit 1: Carbocations and Carbanions: : **(Hours: 11)**

Difference between classical and non-classical carbocations.Introduction of neighboring group participation (NGP), ion-pairs, molecular rearrangements in acyclic, monocyclic, and bicyclic systems, stability and reactivity of bridgehead carbocations.

Carbanions: Generation, structure and stability, ambident ions and their general reactions; HSAB principle and its applications.

Unit 2: Carbenes ***(Hours: 7)***

: Structure of carbenes, generation of carbenes, addition and insertion reactions,rearrangement reactions of carbenes such as Wolff rearrangement, generation and reactions of ylid by carbenoid decomposition. Examples of inter/intramolecular insertions.

Unit 3**: **Nitrenes and Ylide **(Hours:7)**

Structure of nitrene, generation and reactions of nitrene and related electron-deficient nitrogen intermediates, Curtius, Hoffmann, Schmidt, Beckmann rearrangement reactions.
Ylides: Chemistry of Phosphorus and Sulfur ylids – Wittig and related reactions, Peterson olefination.

Unit 4: Radicals: **(Hours: 5)**

Generation of radical intermediates and their addition to: i) on alkenes, alkynes (inter & intramolecular) for C-C bond formation and Baldwin's rules.ii) fragmentation and rearrangements. Name reactions involving radical intermediates, such as Barton deoxygenation and decarboxylation, McMurry coupling.

Practical Component:

Separation, purification, and identification of binary mixtures of organic compounds (neutral and acidic; neutral and basic) using chemical methodsand preparation of a suitable crystalline derivative for both the components. (Examples: (i) Benzoic acid/Any dicarboxylic acid and Naphthalene (ii)*p*-toludine/*p*-anisidine and Naphthalene)

1. **Two-step synthesis**

   2.1 ***Synthesis of triacetoxybenzene***
   *Step 1:*Synthesis of *p*-benzoquinone from hydroquinone using $KBrO_3$ and
   *Step 2:*Synthesis of Triacetoxybenzene from *p*-benzoquinone.

   2.2 ***Synthesis of p-acetamido benzene sulphonamide***
   *Step 1:*Synthesis of *p*-Acetamido benzene sulfonyl chloride from acetanilide and
   Step 2: Synthesis of *p*-Acetamido benzene sulphonamide from *p*-Acetamido benzene sulfonyl chloride.

   2.3 ***Synthesis of benzopinacolone***
   *Step 1:*Synthesis of benzopinacol from benzophenone
   Step 2: Synthesis of benzopinacolone from benzopinacol *via* pinacol-pinacolone rearrangement.

Recommended Reference and Textbooks:

1. A. Carey and R. A. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5th edition, Springer, New York, **2007**.
2. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, First South Asian Edition 2005, Cambridge University Press.
3. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edition, Wiley, **2007**.

For Practicals

1 Vogel, A. I. (**2012**), Quantitative Organic Analysis, Part 3, Pearson Education.
2 Mann, F. G., Saunders, B.C. (**2009**), Practical Organic Chemistry, Pearson Education.
3 Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (**2012**), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.

4 Ahluwalia, V.K., Dhingra, S. (**2004**), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
5 Ahluwalia, V. K., Aggarwal, R. (**2004**), Comprehensive Practical Organic Chemistry: preparation and Quantitative Analysis, University Press
6 Pasricha, S., Chaudhary, A. (**2021**), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
7 Pasricha, S., Chaudhary, A. (**2021**), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 18 (DSE-18)

Advanced Molecular Spectroscopy and Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Molecular Spectroscopy and Applications (DSE-18)	**04**	**02**	**--**	**02**	__	**--**

Learning Objectives:

- Introduce the principles of molecular spectroscopy across electronic, vibrational, rotational, and nuclear domains.
- Apply quantum mechanical concepts such as the Born–Oppenheimer approximation, Heisenberg's Uncertainty Principle, and time-dependent perturbation theory to spectroscopic transitions.
- Use symmetry and operator-based formalisms to derive selection rules.
- Analyze UV-Vis, fluorescence, Raman, Mössbauer, and CD spectroscopy.
- Explore applications in structure elucidation, dynamics, and single-molecule detection.

Learning outcomes

By the end of the course, students will be able to:

- Understand the principles of electromagnetic radiation and molecular transitions.
- Interpret selection rules using quantum and symmetry considerations.
- Analyze vibrational fine structure and electronic transitions using the Franck–Condon principle.
- Describe the principles and applications of fluorescence, phosphorescence, and circular dichroism.
- Apply advanced tools such as Mössbauer spectroscopy, and single-molecule spectroscopy.

SYLLABUS OF DSE 18

Unit 1: Fundamentals & Quantum Background (Hours: 6)

Electromagnetic radiation and spectral regions. Born–Oppenheimer approximation and Uncertainty Principle. Time-dependent perturbation theory (TDPT) and transition moments. Einstein coefficients and derivation of Beer–Lambert law. Selection rules (qualitative) using symmetry and operator formalism.

Unit 2: Electronic Spectroscopy & Photophysical Processes in Molecules (14: Hours)

Electronic transitions in diatomic molecules (π–π^*, n–π^*, n–σ^*, etc.). Selection rules (qualitative). Breakdown of selection rules. Franck–Condon principle and vibrational fine structure. P, Q, R branches in rovibrational spectra. Dissociation energies (e.g. iodine spectrum).

Polyatomic molecules: Chromophores and auxochromes: structure–property relationships. Solvent effects: polarity, hydrogen bonding and solvent shifts, vibronic coupling, Charge transfer (CT) transitions and their spectral features. Qualitative interpretation of UV-Vis spectra of polyatomic organics (e.g. ethene, formaldehyde, cis- and trans-butadiene) using symmetry principles.

Unit 3: Mössbauer Spectroscopy (Hours: 4)

Jablonski diagram, Fluorescence and phosphorescence: mechanisms and applications. Deactivation pathways, internal conversion, intersystem crossing. Mirror-image symmetry and polarization effects in emission spectroscopy.

Mössbauer spectroscopy: Isomer shifts, quadrupole and Zeeman splitting. Applications to oxidation state and bonding.

Unit 4: Advanced Applications (Hours: 6)

Fluorescence quenching (static/dynamic) and lifetime measurements. Single molecule spectroscopy and fluorescence correlation spectroscopy (FCS). Circular Dichroism (CD): principle and biological examples. Mirror-image symmetry and its breakdown. Selection rules and polarization effects.

Forward look: qualitative overview of emerging methods (e.g. AI-assisted spectra interpretation)-non-evaluative.

Practical Component

Laboratory Exercises (Practical) (atleast 10):

1. Analyse UV-Vis absorption spectra of conjugated systems (e.g., β-carotene) and determine the HOMO-LUMO gap.
2. Use UV-Vis spectra of a pH-sensitive dye (e.g., phenolphthalein) to determine its pK_a.
3. Study the effect of structure on the UV spectra of organic compounds.
4. Study the spectra of mesityl oxide/benzophenone in different solvents and classify the observed transitions in terms of $n \to \pi^*$ and $\pi \to \pi^*$ transitions. Discuss the shift in transitions relative to those in acetone.
5. Find the stoichiometry of the charge transfer (CT) complex formed between thiocyanate ions and iron (III) by Job's method of continuous variation.
6. (a) Record the UV spectra of a weak acid (α-naphthol) at different pH and determine the dissociation constant in the ground state.

   (b) Record the fluorescence spectra of a weak acid (α-naphthol) at different pH and determine the dissociation constant in the excited state.

   Comment on the difference in the two values using MO theory.

Instruction Mode: Demonstration/Discussion of working principle/Hands-on with substantial literature analysis/Laboratory exercise

7. Record and compare IR spectra of alcohols in pure form and diluted in non-polar solvents to understand the effect of hydrogen bonding on O-H stretching frequency.
8. Create calibration curve and use it to determine the concentration of a fluorophore (quinine, riboflavin) in unknown samples.
9. Study UV-Vis spectra of d^0 transition metal complexes (e.g., Ti^{3+}) and assign electronic transitions using computational or experimental techniques.
10. Measure absorbance vs. time data to study the kinetics of fast photochemical reactions (using Time-Resolved Absorption Spectroscopy for Reaction Kinetics).
11. Resolve and assign vibrational fine structure in the UV-Vis spectrum of iodine vapour.
12. UV spectra comparison of substituted benzenes (π–π^* vs n–π^*)
13. Fluorescence quenching and lifetime (model system, Rhodamine or naphthol)
14. CD analysis of protein model (experimental or literature spectra)

15. Simulation and analysis of Franck–Condon transitions using potential energy diagrams for diatomic molecules.

16. Interpret Mössbauer isomer shift and quadrupole splitting data from literature spectra of iron complexes.

Recommended References and Text Books: (For Theory)

1. J. Michael Hollas, Modern Spectroscopy, 4th Ed.

2. Rita Kakkar, Atomic and Molecular Spectroscopy, Cambridge University Press
3. C. N. Banwell & E. M. McCash, Fundamentals of Molecular Spectroscopy
4. Satyanarayana, D. N., Handbook of Molecular Spectroscopy, I.K. International
5. P. Atkins & R. Friedman, Molecular Quantum Mechanics
6. Jeanne L. McHale, *Molecular Spectroscopy*
7. **J. Chem. Rev. 2021, 121, 9816–9872 –** *ML + Computational Chemistry*

Recommended References and Text Books: (For Practical's)

1. Rita Kakkar, Atomic and Molecular Spectroscopy, Cambridge University Press.
2. B. D. Khosla, V. C. Garg, A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co., New Delhi.
3. Donald A. McQuarrie & John D. Simon, Physical Chemistry: A Molecular Approach.
4. J. Michael Hollas, Modern Spectroscopy.
5. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis.
6. Jeanne L. McHale, Molecular Spectroscopy.

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 19 (DSE-19)

Interfaces, Macromolecules and Biophysical Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Interfaces, Macromolecules and Biophysical Chemistry (DSE-19)	**04**	**02**	**--**	**02**	__	**--**

Learning Objectives:

- To understand fundamental surface and interfacial phenomena including adsorption, wetting, and catalysis.
- To introduce classification and characterization of polymers, polymerization mechanisms, and molecular weight determination.
- To apply thermodynamics and kinetics to protein folding, ligand binding, and enzyme catalysis.
- To familiarize students with analytical and optical tools used to study biomolecular structure and interactions.
- To bridge molecular understanding with biological function through biophysical chemistry.

Learning outcomes

By the end of the course, students will be able to:

- Explain micellization, surface tension, adsorption isotherms, and thin film properties.
- Describe polymer synthesis, types, and methods for determining molecular weights.
- Analyze biological macromolecules using thermodynamic, kinetic, and statistical models.
- Use key spectroscopic and separation techniques to investigate biomolecular properties.
- Connect experimental methods with structural and functional insights in biophysical chemistry.

SYLLABUS OF DSE 19

Unit-1: Surface and Interface Chemistry (Hours: 8)

Surface-active agents, micellization, hydrophobic interaction, critical micelle concentration (CMC), Krafft temperature.
Packing parameters, thermodynamics of micellization, solubilization, reverse micelles. Electrokinetic phenomena, Young-Laplace and Kelvin equations.
Adsorption: - Gibbs adsorption isotherm, Langmuir and BET isotherms, surface area measurements.
Thin films and Langmuir-Blodgett films.
Catalytic activity at surfaces (overview).

Unit 2: Polymer Structure and Characterization (Hours: 8)

Macromolecules and types of polymerizations, Degree of polymerization, number and mass average molecular masses, Polymer characterization: osmometry, viscometry, light scattering, diffusion.
Glass transition temperature, crystallinity.

Unit 3: Biophysical Chemistry of Macromolecules (Hours: 8)

Isoelectric point of amino acids, Configuration, and conformation of biological macromolecules, Thermodynamics of protein folding/stability, Configurational statistics and conformational transitions, Thermodynamics and kinetics of ligand interactions, Macromolecule-ligand binding and cooperativity (including Hill equation).

Enzyme catalysis: Michaelis-Menten equation (with derivation), Lineweaver-Burk plot, define the turnover number and Michaelis constant, Enzyme inhibition- reversibility and product inhibition

Unit 4: Spectroscopic, Analytical and Separation techniques (Hours: 6)

Basic principles and applications of analytical and optical techniques in biological systems: Absorption and fluorescence spectroscopy (overview only), Isothermal Titration Calorimetry (ITC), Linear and Circular Dichroism (CD), Single and multidimensional NMR spectroscopy. Single molecule spectroscopy.

Methods for the separation of biomolecules: General principles, including Chromatography; Sedimentation, Moving Boundary Sedimentation, Zonal Sedimentation, Electrophoresis, Isoelectric focusing, Capillary electrophoresis, MALDI-TOF.

Practical Component

1. Study of adsorption of Acetic Acid on Charcoal.
2. Conductometric Study of Critical Micellar Concentration.
3. Calculation of the thermodynamic parameters of micellization of SDS surfactant from conductivity/spectroscopic measurements.
4. Determination of pK_a values and the isoelectric point of an amino acid (both acidic and basic) using pH titration against acid and base.
5. Determination of surface area of a surfactant molecule using Gibbs adsorption isotherm.
6. Study of the catalytic efficiency of a non-specific enzyme by measuring the rate of the enzyme-catalysed reaction.
7. Separation of serum proteins using paper electrophoresis/ Ammonium Sulphate fractionation.
8. Molecular docking study for binding interaction of Fluconazole with 14a-demethylase enzyme (lanosterol) of prominent fungal pathogens Candida albicans using protein structure from protein data bank (PDB ID: CYP51) and Open-source software i.e. AutoDock Vina/ Swiss Dock, etc.

Instruction Mode: Demonstration/ Discussion of working principle/ Hands-on with substantial literature analysis/ Laboratory exercise

9. Instruction mode transaction of working principle of CD spectroscopy and demonstrating experimental protocol for determining protein folding and the percent helix, sheet, turns, and random structure change in protein (Bovine Serum Albumin) upon binding with a suitable ligand i.e. Rhodamine B.
10. Instruction mode transaction of working principle of MALDI-TOF instrumentation technique and its application to identify serum proteins (i.e. Bovine Serum Albumin) and their post translational modifications.
11. Instruction mode transaction of working principle of fluorescence spectroscopy and demonstrating experimental protocol for designing fluorescence/phosphorescence-based chemo sensors for detection of amino acid arginine.
12. Experimental Demonstration of the thermodynamics of urea induced denaturation of a protein, bovine serum albumin, by using fluorimetry.

Recommended References and Text Books: (for Theory)

1. Adamson, A. W. & Gast, A. P., Physical Chemistry of Surfaces, 6th Ed., Wiley
2. Somorjai, G. A. & Li, Y., Surface Chemistry and Catalysis
3. Israelachvili, J. N., Intermolecular and Surface Forces
4. Carraher, C. E., Introduction to Polymer Chemistry
5. Odian, G., Principles of Polymerization

6. Cantor, C. R. & Schimmel, P. R., Biophysical Chemistry (3 vols)
7. Wilson, K. & Walker, J., Principles and Techniques of Biochemistry and Molecular Biology
8. Dill, K. A. & Bromberg, S., Molecular Driving Forces
9. Hiemenz, P. C. & Lodge, T. P., Polymer Chemistry
10. Hiemenz, P. C. & Rajagopalan, R., Principles of Colloid and Surface Chemistry.
11 Van Holde, Principles of Physical Biochemistry

Recommended References and Text Books: (for practical's)

1. Voet, D.; Voet, J. G.; Pratt, C. W. Fundamentals of Biochemistry (Fifth Edition), John Wiley & Sons, Inc.
2. Lakowicz, J. R.; Principles of Fluorescence Spectroscopy, Springer Nature; 3rd edition (4 August 2006).
3. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
4. Hiemenz, P. C.; Rajagopalan, R. Principles of Colloid and Surface Chemistry (3rd Edition) MarceldEkkerin, C.
5. Adamson, A. W.; Gast, A. P.; Physical Chemistry of Surfaces, Sixth Editions, John Wiley & Sons, Inc.

SEMESTER – VIII

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 20 (DSE-20)

Transition Metal Clusters-Introduction and Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Transition Metal Clusters-Introduction and Applications (DSE-20)	4	2	--	2	--	--

Learning Objectives:

To introduce the basic concepts of transition metal clusters. To gather a good understanding of the chemistry and various aspects of metal-carbonyl clusters, carboranes, metalloboranes and heteroboranes, metallocarboranes with respect to synthesis, structure and properties.

Learning Outcomes:

On completion of the course, the students will be able to:

- Ensures the students understand the concepts and the properties of transition metal clusters.
- Acquire knowledge of transition metal clusters cluster compounds and explain structure-property, electron counts, and surface analogies of cluster compounds.
- Identify the structure and bonding aspects of transition metal clusters.
- Identify the different types of transition metal clusters reactions and apply the above concepts to explain reactivity of the clusters.
- To study the application of molecular clusters in catalysis.

SYLLABUS OF DSE 20

Unit 1: **(Hours: 12)**

Transition-metal clusters: Low nuclearity metal-carbonyl clusters and 14n+2 rule, high nuclearity metal-carbonyl clusters with internal atoms, polyhedral skeletal electron pair theory (PSEPT), metalloboranes, metallocarboranes.

Unit 2: **(Hours:5)**

Structure, synthesis, bonding aspects and reactivity. Capping rules, metal-ligand complexes vs heteronuclear cluster.

Unit 3: (Hours: 5)

Main-group-Transition-metal clusters: Isolobalanalogs of p-block and d-block clusters, limitations,and exceptions.

Unit 4: (Hours: 8)

Clusters having interstitial main group elements, cubane clusters and naked or Zintl clusters. Chevrel compounds, infinite metal chains, multidecker molecules-cluster surface analogy. Molecular clusters in catalysis, clusters to materials. Illustrative examples from recent literature.

Practical Component

1. Synthesis of ferrocene and its characterisation using IR, ^{1}H NMR and UV-Visible spectroscopy
2. Synthesis of acetylferrocene and its characterisation using IR, ^{1}H NMR and UV-Visible spectroscopy
3. Synthesis of $[Fe(\eta\text{-}C_5H_5)(\eta\text{-}C_6H_6)]PF_6$ using ligand exchange reaction. Characterisation of the product using IR, ^{1}H NMR and UV-Visible spectrum
4. Estimation of metal ions in the mixture solution- Mg^{2+}- Zn^{2+}, Ca^{2+}- Mg^{2+}, Cu^{2+} - Zn^{2+}titrimetrically.
5. Analysis of given transition metal cluster(metal carbonyls) using various spectroscopic techniques - IR, UV-Visible and mass spectrometry.

Keywords: Transition Metal Clusters, metal-carbonyl clusters, carboranes, metalloboranes, heteroboranes, metallocarboranes, Capping rules, Isolobal relationship, interstitial main group elements, cubane clusters and naked or Zintl clusters, Chevrel compounds, catalysis, clusters to materials, boron-carbides, metal-borides, Synthesis, Reactivity.

Recommended Text Books and References

1. M. P. Mingos and D. J. Wales; Introduction to Cluster Chemistry, Prentice Hall, 1990.
2. N. Greenwood and E. A. Earnshaw; Chemistry of elements, Second Edition, Butterworth-Heinemann, 1997.
3. P. Fehlner, J. F. Halet and J-Y. Saillard; Molecular Clusters: A Bridge to solid-state Chemistry, Cambridge University press, 2007.
4. D. Gupta and A. J. Elias; Basic Organometallic Chemistry: Concepts, Synthesis, and Applications, Universities Press (India), 2010.
5. M. P. Mingos, Essential Trends in Inorganic Chemistry, Oxford, University Press, 1998.

6 C.E. Housecroft, Metal-Metal Bonded Carbonyl Dimers and Clusters, Oxford Chemistry Primers (44), Oxford, University Press, 1996.

7 F. Holleman and E. Wifrg, Inorganic Chemistry, Academic Press, New York, 1995.

8 F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley & Sons, Inc, New York, 1999.

9 G. Wulfsberg, Inorganic Chemistry, Viva Books Pvt Ltd, New Delhi, 2001.

10 B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley & Sons, Inc, New York, 2001.

11 P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Shriver & Atkins Inorganic Chemistry, 4th Edn, Oxford, 2006.

12 J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorgnic Chemistry: Principles of Structures and Reactivity, 4th Edn, Pearson, New Delhi, 2006.

13 R. Xu, W. Pang and Q. Huo (Eds), Modern Inorganic Synthetic Chemistry, Elsevier, New York, 2011.

14 G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rd Edn, Pearson, New Delhi, 2009.

15 J. R. Anderson and M. Boudart (Eds), Catalysis: Science and Technology, Springer, London, 2012.

16 P. Powell, Principles of Organometallic Chemistry, 2nd Edn, Chapman and Hall, London, 1988.

17 G. O. Spessard and G. L. Miessler, Organometallic Chemistry, International 2nd Edn, Oxford University Press, Oxford, 2010.

18 D. F. Shriver, H. D. Kaesz and R. D. Adams (Eds), The Chemistry of Metal Cluster Complexes, VCH, New York, 1990.

19 K. J. Klabunde, Free Atoms, Clusters and Nanoscale Particles, Academic Press, New York, 1994.

20 D. M. P. Mingos (Ed.), Structural and Electronic Paradigms in Cluster Chemistry, Springer, Berlin, 1997.

21 P. Braunstein, L. A. Oro and P. R. Raithby (Eds), Metal Clusters in Chemistry, Wiley-VCH, Weinheim, 1999.

22 M. Driess and H. Noth (Eds), Molecular Clusters of the Main Group Elements, Wiley-VCH, Weinheim, 2004.

23 C. E. Housecraft and A. G. Sharpe, Inorganic Chemistry, 3rd Edn, Pearson Education Ltd, Essex, England, 2008.

24 F. Wells, Structural Inorganic Chemistry, 5th Edn, Oxford University Press, Oxford, 1984.

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 21 (DSE-21)

Advanced Analytical Techniques for Inorganic Compounds

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Analytical Techniques for Inorganic Compounds (DSE-21)	**4**	**2**	**--**	**2**	--	**--**

Learning Objectives

This course is to equip students in handling advanced analytical instruments and techniques important for analysing inorganic compounds.

Learning outcomes

- By the end of the course, the students will be able to:
- To apply the fundamentals of various types of spectroscopic techniques like UV, IR, EPR and Mossbauer spectroscopy and applications of these techniques to interpret data.
- To describe the advancement in spectroscopic methods like IR, UV, EPR and Mossbauer and can recognize necessity of these techniques in the field of analytical science.
- To perform quantitative and qualitative measurements of samples by IR, UV.
- To use different techniques like liquid-liquid extraction, counter current extraction, digestion and solid phase extraction for sample preparation
- To be able to identify, recognize and compare principle, instrumentations and application of Atomic Absorption Spectroscopy (AAS), inductively coupled plasma atomic emission spectroscopy (ICP-AES),

SYLLABUS OF DSE-21

Unit 1: **(04 Hours)**
Purification and drying of solvent. Reagents used in undergraduate laboratory: preparation, purification and handling.

Unit 2: **(10 Hours)**

Introduction, Physical and Chemical Principles, Spectrometers, Detection, Calculation, and Output, Analytical Information: Qualitative and Quantitative, Applications

Instrumental techniques in laboratory: Infrared spectrophotometer, UV-Visible spectrophotometer. Column chromatography and metal ions separation through ion exchange chromatography.

Unit 3: **(10 Hours)**

Atomic Absorption and Emission Spectrometry: Introduction, hollow cathode lamp as a source and its working, premix chamber burner and total consumption burner, Flame atomizer - principle and working mechanism of electrothermal atomizers, line width, different interferences observed in AAS. Inductively Coupled Plasma Atomic Emission Spectroscopy.

Unit 4: **(06 Hours)**

Introduction to EPR and Mossbauer spectroscopy and their Applications.

Keywords: Solvent, Reagents Infrared spectrophotometer, UV-Visible spectrophotometer. Column chromatography, Ion exchange chromatography, AAS, ICP-AES, EPR and Mossbauer spectroscopy

Practical Component:

1. Preparation of VO (acac)$_2$ and its characterisation by determining magnetic moment, UV-Visible and IR spectroscopy.
2. Separation of Ni^{2+} and Zn^{2+} in the given mixture through column chromatography.
3. Preparation of $[Co(en)_3]Cl_3$, *cis*- and *trans*- $[Co(en)_2Cl_2]Cl$by oxidation of $Co^{2+}$and measurement of their optical activity.
4. Spectrophotometric estimation of Cr^{3+} in the given solution by 1,5-diphenylcarbazide
5. Estimation of Cu^{2+}-Fe^{3+}/Cu^{2+}-Bi^{3+} in the mixture solution with EDTA spectrophotometrically.
6. Synthesis of any ligand of choice (for example- carboxylate, ester, Schiff base, amides, amines etc.).
7. Synthesis of a transition metal complex using above ligand
8. Characterisation of above complex using suitable analytical technique
9. To determine the solubility and solubility product of a sparingly soluble electrolyte conductometrically.

Recommended Textbooks and references (For Theory)

1. Fundamentals of Analytical Chemistry by Crouch, West and Skoog,9th edition , Brooks/Cole(2013)
2. Analytical Chemistry, Gary D. Christian, 6th Edition, John Wiley and Sons Inc. New Jersey,2007.
3. Instrumental Methods of Chemical Analysis, by Galen W. Ewing, 4thEdition, International Student Edition, 1969.
4. Instrumental methods of analysis, 7th Ed, Willard, Merritt, Dean, SettleCBS Publishers & Distributors 2004.

Recommended Textbooks and references (For Practical)

1 Advanced practical inorganic chemistry, D.M. Adams, J.B. Raynor John Wiley & Sons Ltd 1965

2 Advanced practical organic chemistry, 2nd Ed. Leonard, Lygo, Procter.CRC Press; 3rd edition 2013

3 Inorganic experiments, J.D. Woollins, Wiley VCH 2009

4 General Chemistry Experiments. Anil J. Elias, universities press,2016.

5. Fundamentals of Analytical Chemistry, Skoog and West's, 9th Edition, Cengage Learning Publisher, 2014.

6. Analytical Chemistry-An Indian Adaption,Gary D Christian, Purnendu K Dasgupta, Kevin A Schug , Wiley India Pvt.Ltd,2020.

7. Specrochemical Analysis by Atomic Absorption and Emission, Lajunen L H J, Cambridge, UK: The Royal Society of Chemistry, 1992.

8. Advances in Atomic Spectroscopy, Sneddon J, CT: JAI Press, Greenwich, 1992.

9. CRC Handbook of Inductively Coupled Plasma Atomic Emission Spectrometry, Varma A, FL: CRC Press, Boca Raton, 1991.

GE (2+2) Credit

The existing pool of GE papers of Chemistry can be extended to VII and VIII semesters.

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 22 (DSE-22)

Fundamentals of Natural Products

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Fundamentals of Natural Products (DSE-22)	**4**	**2**	**--**	**2**	--	**--**

Learning Objectives:

The primary objective of this course is to provide students with a comprehensive understanding of natural product chemistry, including its historical development, modern applications, classification, biosynthesis, and methods for isolation and purification.

Learning Outcomes:

By the end of this course, students will understand the scope and significance of natural product chemistry in both historical and modern contexts, particularly its role in drug discovery. Students will classify major natural product groups-such as alkaloids, terpenoids, flavonoids, phenolics, peptides, glycosides, polyketides, steroids, and hormones-and understand their structures and functions.

SYLLABUS OF DSE 22

Unit 1: Introduction ***(4 Hours)***

Definition and scope of natural product chemistry, historical significance and modern relevance, Primary vs secondary metabolites, Sources of natural products: terrestrial and marine origin, importance in drug discovery and development.

Unit 2: Classification of Natural Products: **(7 Hours)**

Alkaloids, Terpenoids, Flavonoids, Phenolics, Peptides and Proteins, Glycosides, Polyketides, Steroids and Hormones (structure and function only).Isoprene rule, mevalonate and non-mevalonate pathways, Shikimic acid pathways.

Unit 3: Isolation and Purification Techniques **(4 Hours)**

Extraction methods (solvent extraction, Soxhlet, maceration, etc.), Chromatographic techniques (TLC, Column, HPLC, GC-MS), Crystallization and distillation techniques, Bioassay-guided fractionation.

Unit 4: Total Synthesis of Natural Products **(15 Hours)**

Artemisinin (Antimalarial);Berberine (anti-inflammatory); Lysergic Acid Diethylamide(Psychedelic drug).

Biosynthesis of Natural Products:Artemisinin, Berberine, and Lysergic Acid Diethylamide (LSD).

Practical component

1. Isolation of natural products: Isolation of β-carotene from carrots.

2. Isolation of natural products: Isolation of caffeine from tea leaves.

3. Isolation of natural products: Isolation of piperene from black pepper.

4. Isolation of natural products: Isolation of eugenol from cloves.

5. Synthesis of 7-hydroxy-4-methylcoumarin

6. Synthesis of a simple dipeptide(gly-gly)by DCC coupling using N-protected amino acids.

7. Synthesis of simple amino acids

Recommended Reference and Textbooks (For Theory)

1. Mann, J.; Davidson, R. S. & Hobbs, J. B.,**Natural Products: Their Chemistry and Biological Significance, Longman Scientific & Technical (1994)**
2. Mann, J. Secondary Metabolites, Oxford University Press, Oxford, UK, (**1980**)
3. Hanson, J. R., **Natural Products:The Secondary Metabolites, The Royal Society of Chemistry, Cambridge, UK (2003)**
4. Chatwal, G.,**Organic Chemistry of Natural Products, Himalaya Publishing House (1994).**

Recommended Reference and Textbooks (For Practical)

1 Vogel, A. I. (**2012**), Quantitative Organic Analysis, Part 3, Pearson Education.

2 Mann, F. G., Saunders, B.C. (**2009**), Practical Organic Chemistry, Pearson Education.

3 Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (**2012**), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.

4 Ahluwalia, V.K., Dhingra, S. (**2004**), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

5 Ahluwalia, V. K., Aggarwal, R. (**2004**), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press

6 Pasricha, S., Chaudhary, A. (**2021**), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi

7 Pasricha, S., Chaudhary, A. (**2021**), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 23 (DSE-23)

Fundamentals of Medicinal Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Fundamentals of Medicinal Chemistry (DSE-23)	**4**	**2**	**--**	**2**	--	**--**

Learning Objectives

This course aims to introduce students to the foundational concepts of medicinal chemistry, highlighting its historical development and the significance of natural products as drug sources. Additionally, the course examines the structure, synthesis, therapeutic use, and basic SAR of key drugs like Ibuprofen, Paracetamol, Aspirin, and Penicillin.

Learning Outcome:

By the end of the course, students will be able to explain the development and role of medicinal chemistry, understand the stages of drug discovery, and evaluate drug screening and clinical processes. They will interpret how stereochemical and physicochemical properties influence drug behavior and efficacy.

SYLLABUS OF DSE 23

Unit 1:Introduction **(7 Hours)**

: History and development of medicinal Chemistry. Sources of drugs, including natural products with examples, Stages of drug discovery, Stereochemical aspects, Physicochemical properties: solubility, acid-base, partition coefficient.

Unit 2:Drug discovery: **(8 Hours)**

Target identification and validation, Screening of drugs, High throughput screening (HTS), Random and Systematic screening. Structure activity relationship (SAR), Hit identification, and Lead optimization. `

Unit 3: Pharmacokinetics (ADME) and Bioinformatics: **(8 Hours)**

Drug administration/absorption, drug distribution, drug metabolism - Phase 1 and Phase 2, drug excretion, Half-Life of drugs, and Clinical trials. :Use of computational tools for drug design.

Unit 4:Representative Synthetic Drugs: **(7 Hours)**
Structure, Synthesis, and Therapeutic Valueof Representative Drugs:Fluconazole (antifungal), Penicillin (antibiotic), Isoniazid (antibiotic),and Azidothymidine (AZT; anti-HIV).

Practical Component

1. Isolation and estimation of aspirin from commercial tablets
2. Synthesis of paracetamol from *p*-aminophenol
3. Synthesis of benzotriazole/benzimidazole.
4. Synthesis of 5,5'-Diphenylhydantoin.
5. Synthesis of dihydropyridine (DHP)/dihydropyrimidine (DHPM).
6. Study of physicochemical properties of pharmaceutically active compounds using computational methods.

Recommended Reference and Textbooks: (For Theory)

1. Patrick, G. L. *Introduction to Medicinal Chemistry*, Oxford University Press (2001)
2. Lemke, T. L. & William, *D. A., Foye's Principles of Medicinal Chemistry*, 5th Ed., USA (2002)
3. Dunlap, N. K. &Huryn, D. M., *Medicinal Chemistry*, Garland Science, New York (2018)
4. Mark W. Holladay, Richard B. Silverman.*The Organic Chemistry of Drug Design and Drug Action,* 3rd Ed. Academic Press (**2014**)

Recommended Reference and Textbooks: (For Practical)

1 Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.

2 Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.

3 Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.

4 Ahluwalia, V. K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

5. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
6. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
7. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 24 (DSE-24)

Interfacial Electrochemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Interfacial Electrochemistry (DSE-24)	4	2	--	2	--	--

Learning Objectives:

- To introduce the structure and thermodynamics of electrochemical interfaces including models of the electric double layer.
- To explain electrode kinetics with emphasis on Butler-Volmer kinetics, Tafel plots, and cyclic voltammetry.
- To introduce Marcus theory and concepts of electrocatalysis and corrosion with real-world relevance.
- To explain transport in electrolyte solutions using laws of diffusion laws, Debye-Hückel theory, and transport numbers.
- To explore adsorption thermodynamics and applications of electrochemical principles in energy storage and conversion devices.

Learning Outcomes:

By the end of the course, students will be able to:

- Explain and compare models of electric double layer and relate them to interfacial properties.
- Apply the Butler-Volmer equation and cyclic voltammetry to interpret reaction mechanisms.
- Describe Marcus theory and the role of parameters in HER, OER and corrosion control.
- Interpret adsorption isotherms and thermodynamic data related to interface processes.
- Evaluate electrochemical energy devices like fuel cells, batteries and supercapacitor

SYLLABUS OF DSE 24

Unit 1: Structure and Thermodynamics of Electrochemical Interface (Hours: 5)

Overview of interfaces and electrochemical systems.Electric Double Layer: Models: Helmholtz Model, Gouy-Chapman Model (derivation), Stern Model, Graham-Devanathan-Mott-Watts model, Tobin, Bockris-Devanathan model, Thermodynamics of the EDL

Electrocapillary phenomena

Unit 2: Electrode Kinetics and Cyclic Voltammetry (6 Hours)

Standard, formal and equilibrium potentials, Overpotentials and their types, Butler-Volmer equation: Derivation and its physical implications, Exchange current density and transfer coefficient, Tafel equation and graphical interpretation, Cyclic voltammetry: Theory and experimental design. Distinguishing reversible, quasi-reversible, irreversible, and capacitive processes.

Unit 3: Electron Transfer and Electrocatalysis and Transport in Electrolytes (Hours: 9)

Marcus theory (qualitative description only): activationless region, reorganization energy

Introduction to electrocatalysis, Parameters influencing HER, OER, and oxygen reduction reaction (ORR), Role of electrode material. Ionic mobility and transport number, Fick's laws of diffusion, Einstein equation for diffusion. Debye–Hückel–Onsager limiting law, Electrophoretic and relaxation effects, time of relaxation. Dependence of transport number on concentration

Unit 4: Adsorption, Surface Thermodynamics and Corrosion & its control (10 hours)

Adsorption of ions and molecules at interfaces, Thermodynamic treatment of adsorption

Adsorption isotherms:Langmuir, Frumkin, Temkin, Determination of surface excess and charge

Types of corrosion: uniform, galvanic, pitting, crevice, etc., Thermodynamics and kinetic aspects.

Monitoring methods: electrochemical noise, impedance, Inhibition and protective coatings.

Electrochemical Energy Conversion and Storage**:** Fuel cells: PEMFC, Alkaline, Methanol, Batteries: Lithium-ion, Redox flow, Supercapacitors: EDLC and pseudocapacitors. Comparative performance and limitations

Practical Component

1. Conductometric Titration of a Charge Transfer System, the formation of charge transfer complex between an electron donor and acceptor is studied and the stoichiometry of the complex is determined by following the variation of conductance of the solution with concentration of the donor and acceptor.

2. Study of the oscillating reaction using the Ce^{3+}/Ce^{4+} system; and the dependence of the oscillation period on the metal ion concentration.
3. Intercalation of sodium into vanadium oxide and potentiometric estimation of extent of intercalation.
4. Effect of ionic strength on reaction rate (persulfate-iodine reaction).
5. Potentiometric determination of solubility and solubility product of AgCl(s) in water.
6. Potentiometric determination of mean ionic activity coefficient of HCl at different concentrations.
7. Potentiometric titration of Phosphoric acid vs NaOH.
8. Determination of dissociation constant of acetic acid from its potentiometric titration curve.

<u>Instruction Mode:</u>Demonstration/ Discussion of working principle/ Hands-on with substantial literature analysis/ Laboratory exercise

9. Record cyclic voltammogram for the electrochemical capacitors (electric double layer) response with varying scan rates,

i) plot anodic and cathodic plateau currents vs scan rates.

(Use aqueous solution of 1.5 M $NaNO_3$)

10. Record cyclic voltammogram for a reversible heterogeneous electron transfer system with varying scan rates,

(i) Determine anodic and cathodic peak current ratio.

(ii) Determine anodic and cathodic peak potential difference.

(iii) Plot peak current vs square root of scan rates.

(Use aqueous solution of 10 mM $K_4Fe(CN)_6$ + $K_3Fe(CN)_6$ + 1.5 M $NaNO_3$)

11. Record cyclic voltammogram for a quasi-reversible heterogeneous electron transfer system with varying scan rates,

(i) Determine anodic and cathodic peak current ratio.

(ii) Determine anodic and cathodic peak potential difference.

(iii) Plot peak current vs square root of scan rates.

(Use aqueous solution of 10mM $Fe(NH_4)_2 (SO_4)_2$ + $Fe(NH_4)(SO_4)_2$ + 1 M $HClO_4$)

12. Record the CV of aqueous solution of sulphuric acid (0.5 M) at Pt electrode as working electrode and counter electrode.

(i) Interpret and explain various peaks and region of the CV and their significance.

Determine the area and roughness factor of the electrode by Pt oxide region.

Recommended References and Text Books: (For theory)

1. Bard, A. J. Faulkner, L. R. Electrochemical Methods: Fundamentals and Applications, 2nd Ed., John Wiley & Sons: New York, 2002.
2. Oldham, K. B., Myland, J. C. and Bond, A. M. Electrochemical Science and Technology: Fundamental and Applications, John Wiley & Sons, Ltd. (2012).
3. Bagotsky, V.S., Fundamentals of electrochemistry 2nd Ed. Wiley – Interscience, (2006)

Supplementary References

1. Bockris, J. O' M. & Reddy, A. K. N. Modern Electrochemistry 1: Ionics 2nd Ed., Springer (1998).
2. Bockris, J. O' M. & Reddy, A. K. N. Modern Electrochemistry 2B: Electrodics in Chemistry, Engineering, Biology and Environmental Science 2nd Ed., Springer (2001).
3. Bockris, J. O' M., Reddy, A. K. N. & Gamboa-Aldeco, M. E. Modern Electrochemistry 2A: Fundamentals of Electrodics 2nd Ed., Springer (2001).
4. Brett, C. M. A. & Brett, A. M. O. Electrochemistry, Oxford University Press (1993).
5. Koryta, J., Dvorak, J. & Kavan, L. Principles of Electrochemistry John Wiley & Sons: NY (1993).
6. Hamann, Carl H., Hamneff, Andrew &Vielstich, Wolf., Electrochemistry, 2nd Ed. (2007)

Recommended References and Text Books: (For practicals)

1. Elgrishi, N.; Rountree, K. J.; McCarthy, B. D.; Rountree, E. S.; Eisenhart, T. T.; Dempsey, J. L. A Practical Beginner's Guide to Cyclic Voltammetry, *J. Chem. Educ.***2018**, *95*, *2*, 197–206.
2. B. D. Khosla, V. C. Garg, A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
3. Field, R. J.; Schneider, F. W. Oscillating Chemical Reactions and Nonlinear Dynamics, *J. Chem. Educ.***1989**, *66*, *3*, 195–204.

DISCIPLINE-SPECIFIC ELECTIVE COURSE - 25 (DSE-25)

Fundamentals of Solid-State and Materials Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Coursetitle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Fundamentals of Solid-State and Materials Chemistry (DSE-25)	4	2	--	2	--	--

Learning Objectives:

- To introduce solid-state and wet chemical synthesis methods, and basics of nanomaterials.
- To explain electronic properties of solids using band theory.
- To understand crystal structures, symmetry, and structure determination via diffraction techniques.
- To use thermal and spectroscopic techniques to characterize materials.
- To explore magnetic properties and structure via electron and atomic force microscopy.

Learning outcomes:

By the end of the course, students will be able to:

- Apply solid-state and chemical synthesis methods to create nanomaterials.
- Interpret band structures and explain properties of metals, insulators, and semiconductors.
- Analyze crystallographic data using symmetry concepts and X-ray/electron diffraction.
- Characterize materials using TGA, DSC, UV-Vis, FTIR, PL, and NMR.
- Evaluate magnetic ordering and interpret SEM, TEM, and AFM data.

SYLLABUS OF DSE 25

Unit 1: Materials Synthesis and Nanochemistry **(Hours: 6)**

Solid state reaction and wet chemical synthetic routes, Top down and bottom-up approach to prepare different kinds of nanomaterials, Fundamental concept of nanoscience including quantum confinement effect, Examples: ZnO, TiO_2, Ag nanoparticles.

Unit 2: Structure and Bonding in Solids **(Hours: 12)**

Fundamentals of lattice including Bravais Lattices, crystal's direction and planes, symmetry operations and symmetry elements, point group, space group and crystal structures, Miller indices, Types of closed packed structures, Factors which influence crystal structures,Introduction to band theory. Metals, insulators and semiconductors, Electronic structure, k-space and Brillouin zones (qualitative).

Bragg condition and Bragg method, Laue method, PXRD: principles and instrumentation, Crystallite size (Scherrer) and Williamson-Hall method to determine lattice strains from diffraction patterns, Basics of Single Crystal X-ray diffractometer (SCXRD), electron and neutron diffraction.

Unit 3- Spectroscopy and Thermal Analysis **(Hours: 6)**

UV-Visible, FTIR, Photoluminescence (PL) and NMR techniques to understand materials properties, Thermogravimetric analysis (TGA), differential thermal analysis (DTA) and differential scanning calorimetry (DSC), principles and interpretation, Examples: thermal decomposition, phase changes.

Unit 4: Advanced Characterization and Magnetic Properties **(Hours: 6)**

Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Atomic Force Microscope (AFM): working principles and applications, Magnetic behaviour: Curie and Curie-Weiss laws, magnetic ordering, exchange interactions, Hysteresis, anisotropy, paramagnetism, ferromagnetism, ferrimagnetism, antiferromagnetism.

Practical Component

Hands-on experiment

1. Synthesis of oxide nanomaterials (e.g., ZnO, TiO_2) using solid-state or sol-gel methods.
2. Preparation of semiconducting CdSe, ZnSe, In_2S_3 (any of one) nanomaterials by any soft chemical approach (emulsion based, co-precipitation etc.).
3. Preparation of metal nanoparticles (e.g., Ag, Cu, or Ni) using standard reduction and capping agents.
4. Studying photocatalytic degradation of environmentally pollutant dye (Crystal Violet, Rhodamine B, methyl orange etc.) by any semiconducting (In_2S_3, CdSe, ZnO- any one) or metallic nanoparticles under visible light irradiation and using UV-Visible spectrophotometer.

5. Determination of congruent composition and temperature of a binary system (e.g. diphenylamine-benzophenone system).
6. Determination of glass transition temperature of a given salt (e.g. $CaCl_2$) conductometrically.
7. Understanding the differences of functional groups by FTIR analysis of different organic compounds (For example, acids, carbonyls, esters, phenolic OH groups etc.).
8. Determination of band gap of a semiconducting nanoparticle (in solution) using UV-visible spectrophotometer.
9. Determination of band gap of a semiconducting nanoparticle (in solid) using UV-visible spectrophotometer (DRS mode).

Analysis of Compounds/Sample with pre-recorded spectra/diffraction patterns and images subject to availability of instruments

1. Measurement and interpretation of different spectra from UV-Vis, IR and NMR using organic, inorganic compounds and molecules. [At least 6 spectra (two from each category) to be provided to students for analysis].
2. Analysis of diffraction pattern obtained from Powder X-ray diffractometer etc (calculation of crystallite size using Scherer equation and lattice strain calculation using Williamson-Hall equation etc). [At least two diffraction patterns of known sample can be provided to students for analysis]
3. Thermogravimetric analysis of compound, molecules etc.
4. Structural analysis using SEM images, EDX analysis of known samples. Students can be provided SEM images and others for analysis.
5. Calculation of particle sizes, aspect ratio from low magnification TEM images of known samples and lattice plane/d spacing calculations from HRTEM images.
6. Facility (PXRD, SCXRD, TEM, SEM and NMR) visits of the students.

Recommended References and Textbooks: (For theory)

1. H. V. Keer, Principles of the Solid State, Wiley Eastern.
2. W. D. Callister, Materials Science and Engineering, Wiley.
3. C. N. R. Rao, Nanomaterials Chemistry: Recent Developments and New Directions, Wiley-VCH.
4. R. S. Drago, Physical Methods in Chemistry, Saunders College.
5. Ray Egerton, Physical Principles of Electron Microscopy, Springer.
6. Principles of Fluorescence Spectroscopy by Joseph R Lakowicz
7. Fundamentals of Molecular Spectroscopy by C. N. Banwell
8 Introduction to Molecular Spectroscopy, G. M. Borrow, McGraw Hill.

Supplementary reading

1. Ashcroft & Mermin, Solid State Physics, Saunders College

Recommended References and Textbooks: (For practical)

1. B.D. Khosla, V.C. Garg and Adarsh Gulati, Senior Practical Physical Chemistry, R. Chand & Co.
2. J.N. Gurtu, Advanced Physical Chemistry Experiments, Pragati Prakashan.
3. G.N. Mukherjee, University Handbook of Undergraduate Chemistry Experiments, Univ. of Calcutta.
4. Ian M. Watt, The Principles and Practice of Electron Microscopy.
5. Ray F. Egerton, Physical Principles of Electron Microscopy – An Introduction to SEM, TEM and AFM.
6. Yoshio Waseda et al., X-ray Diffraction Crystallography: Introduction, Examples and Solved Problems.
7. Journal articles and datasets from ACS, RSC, Elsevier, as applicable (Ind. Eng. Chem. Res. 2014, 53, 3131−3139; ChemSusChem 2011, 4, 1796−1804; ACS Appl. Mater. Interfaces 2017, 9, 11651−11661; Journal of Luminescence 2007, 124, 327–332)

Annexure-10

SYLLABUS FOR INDUSTRIAL CHEMISTRY
Semester VII & VIII
Details of Discipline Specific Core and Elective (DSC &DSE) courses

Course Code	**Name of the course**	**Credits** **T- Theory Credits** **P- Practical Credits**
Industrial Chemistry DSC-7	Dyes: Preparation and properties	T=2 P=2
Industrial Chemistry DSC-8	Polymers and Plastics	T=2 P=2
Chemistry DSE-1	Main Group Clusters - Basics and Applications	T=2 P=2
Chemistry DSE-2	Advanced Coordination Chemistry	T=2 P=2
Chemistry DSE-3	Transition Metal Clusters-Introduction and Applications	T=2 P=2
Chemistry DSE-4	Advanced Analytical Techniques for Inorganic Compounds	T=2 P=2
Chemistry DSE-5	Fundamentals of Natural Products	T=2 P=2
Chemistry DSE-6	Fundamentals of Medicinal Chemistry	T=2 P=2
Chemistry DSE-7	Advanced Stereochemistry	T=2 P=2
Chemistry DSE-8	Reactive Intermediates of Organic Chemistry	T=2 P=2
Chemistry DSE-9	Advanced Molecular Spectroscopy and Applications	T=2 P=2
Chemistry DSE-10	Interfaces, Macromolecules and Biophysical Chemistry	T=2 P=2
Chemistry DSE-11	Mathematical Methods in Chemistry	T=2 P=2
Chemistry DSE-12	Interfacial Electrochemistry	T=2 P=2
Chemistry DSE-13	Fundamentals of Solid-State and Materials Chemistry	T=2 P=2
Chemistry DSE-14	Fundamentals of Solid-State and Materials Chemistry	T=2 P=2

***The Discipline Specific Elective (DSE's) papers have been taken from the syllabus of B Sc (H) Chemistry.**

SEMESTER VII

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Dyes: Preparation and properties (DSC-7)	04	02	--	02	Class 12th with Physics, Chemistry	--

CourseObjectives:

The paper imparts basic knowledge of dyes, properties of dyes and mode of action. This paper is designed in such a way that it will enrich students with the knowledge of various types of dyes, their preparations and applications. The paper has been drafted to impart the theoretical and practical knowledge of dyes with the view of their industrial applications.

Learning Outcomes:

By the end of this course, students will be able to:

- Establish an appreciation of the role of dyesin industrial applications.
- Gain sound knowledge of various types of dyes.
- Get skilled in the scientific method of planning, developing, conducting, reviewing and reporting experiments.
- Get skilled concepts of dyes which will help them to explore new innovative areas of research.

Unit I Hours: 6

Definition of dyes and pigments.Historical development of dyes – from natural to synthetic.The concept of color and constitution (chromophore-auxochrome theory, resonance and molecular orbital theory).

Unit II Hours: 10

Classification of dyes: based on origin (natural/synthetic), chemical structure, and application. Important dye classes: azo, anthraquinone, indigoid, triphenylmethane, phthalocyanine, sulphur based dyes, vat, reactive, disperse, and mordant dyes. Mechanisms of dye synthesis (emphasis on azo coupling).Basic structure-property relationships.

Unit III Hours: 6

Methods of dyeing (batch, continuous, and semi-continuous processes). Dyeing of different fibres: cotton, wool, silk, polyester, nylon.fastness properties (light, wash, rub) and testing. Textile printing techniques.

Unit IV Hours: 8

Impact of dyes on the environment and human health.Treatment of dye effluents – physical, chemical, and biological methods.

Natural dyes – sources, extraction, and limitations.Advances in eco-friendly synthetic dyes.Enzymatic dyeing, waterless dyeing technologies (e.g., supercritical CO_2).Case studies from Indian traditional practices (e.g., indigo dyeing, Kalamkari).

Practical

(Credits: 2, Laboratory periods: 60)

1. Synthesis of Methyl Orange (e.g.,Azo Dye)

2. Synthesis of Malachite Green (Triphenylmethane dye).

3. Dyeing of Cotton using Reactive Dye

4. Dyeing of Wool/Silk using Acid Dye

5. Dyeing (Mordant) of Cotton with Natural Dye (e.g., Turmeric, Henna, Madder) Using alum, ferrous sulfate, or tannins as mordants.

6. Testing of Color Fastness to Washing (ISO Method)

7. Testing Color Fastness to Rubbing

8. Determination of pH of dyed fabrics and dye baths

9. Decolorization of Dye Effluent Using Adsorption (Activated Charcoal /Natural Clays)

10. Extraction of Natural Dye from Plant Sources (Onion Peels, Marigold, Beetroot) and Application on Cotton or Paper

References (Theory):

1. "Chemistry of Synthetic Dyes" – K. Venkataraman
2. "Textile Dyeing" – Peter Hauser
3. "Handbook of Natural Colorants" – Thomas Bechtold& Rita Mussak
4. Relevant UGC & BIS guidelines

References (Practical):

1. Shore, J. (1995). Colorants and Auxiliaries: Volume 2: Auxiliaries. Society of Dyers and Colourists.

2. Broadbent, A. D. (2001). Basic Principles of Textile Coloration. Society of Dyers and Colourists.[

3. Trotman, E. R. (1984). Dyeing and Chemical Technology of Textile Fibres. Charles Griffin & Company.

4 Vogel's Textbook of Organic Chemistry.

Assessment Methods:

All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

Keywords:

Dyes, Natural and Synthetic dyes, Classification of dyes, Structure-properties relationship of dyes, Application of dyes, Environmental aspects of dyes.

Details of Discipline Specific Elective (DSE) courses

Course Code	Name of the course	Credits T- Theory Credits P- Practical Credits
Chemistry DSE-1	Main Group Clusters - Basics and Applications	T=2 P=2
Chemistry DSE-2	Advanced Coordination Chemistry	T=2 P=2
Chemistry DSE-5	Fundamentals of Natural Products	T=2 P=2
Chemistry DSE-6	Fundamentals of Medicinal Chemistry	T=2 P=2
Chemistry DSE-9	Advanced Molecular Spectroscopy and Applications	T=2 P=2
Chemistry DSE-10	Interfaces, Macromolecules and Biophysical Chemistry	T=2 P=2
Chemistry DSE-11	Mathematical Methods in Chemistry	T=2 P=2

***The Discipline Specific Elective (DSE's) papers have been taken from the syllabus of B Sc (H) Chemistry**

SEMESTER VIII

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Polymers and Plastics(DSC-8)	04	02	--	02	Class 12th with Physics, Chemistry	--

Course Objectives:

The paper imparts basic knowledge of polymers and plastics their properties and applications. The paper is designed in such a way that it will enrich students with the knowledge of various types of polymers such as Thermoplastic, thermosetting and elastomers.

Learning Outcomes:

By the end of this course, students will be able to:

- Develop the use ofpolymersin industrial applications.
- Gain sound knowledge of various types of polymers.
- Design and use of scientific method of planning, developing, conducting, reviewing and reporting experiments.
- Get skilled concepts of industrial and environmental friendly polymers which will help them to explore new innovative areas of research.

Unit 1 **Hours: 10**

Introduction to polymers and their applications, Classifications: Natural and Synthetic polymers,Conducting polymer, Thermoplastics, Thermosets, and Elastomers, Structure property relationship,Polymer properties: molecular weight, mechanical, thermal, electrical, and optical. Basics of polymerisation reaction,: condensation, addition, metathesis, ringopening polymerisation and kinetics and types.

Unit 2 **Hours: 6**

Industrial manufacturing of the monomers and their polymers: Polystyrene, Polyethene, Polyacrylonitrile, Polymethylmethacrylate, Polybutadiene, Polycarbonates, Polyurethanes, Nylon(6:6 and 6:10), and Poly-sulphone.

Unit 3 **Hours: 8**

Polymer modification and Processing: Polymer additives: Fillers, Plasticiser, stabiliser, Blowing agent and Colorants. Compounding, compression moulding, injection moulding, extruder and calendar.

Unit 4 **Hours: 6**

Degradation and Recyclingof Plastic and biodegradability: Mechanism and limitations of thermal degradation and biodegradation.Importance of plastic recycling and different methods:.Mechanical recycling(sorting, shredding andreprocessing), Chemical Recycling, and biological recycling.

Practical

(Credits: 2, Laboratory periods: 60)

1. Preparation of Maleic Anhydride/ glyptal resin.

2. Preparation of Caprolactum.

3. Preparation of Polystyrene by bulk polymerisation..

4. Preparation of phenol formaldehyde and urea formaldehyde resins.

5. Preparation of hexamethylenediamine and Adipic acid.

6. Preparation of nylon 6,6.

7. Molecular weight determination of a polymer (nylon 6,6) by end group analysis.

8. Biodegradability of polymer by soil burial Test.

9. Preparation of a flexible film of polyvinyl alcohol by solvent casting and reportits physical

Properties (Thickness/ Strength) .

References (Theory):

1. Plastic Materials; by J. A. Brydson

2. Polymer Science; by V.R. Gowariker, N.V. Viswanathan, and JayadevSreedhar

3. Textbook of Polymer Science; by Fred W. Billmeyer Jr.

4. Principles of Polymerization by George Odian

5. Handbook of Plastic Processes; edited by Charles A. Harpe

6. Plastics and the Environment; by Anthony L. Andrady

References (Practical):

1.Experiments in Polymer Science by D G Hundiwale, V D Athawale, U R Kapadi and V VGite.
2. Practical's in Polymer Science by Siddaramaiah, CBS Publisher.
3. Practical Polymer Analysis by T R Crompton, Springer
4. Experimental methods in polymer science: modern methods in polymer research and technology, Elsevier.
5.Handbook of polymer testing: physical methods by Brown R., CRC Press
6. Polymer ChemistryA practical approach by Fred-J-Davis, Oxford.

Assessment Methods:

All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

Keywords:

Polymer, Thermoset polymers, Thermoplastic polymers, Polymer additives: Fillers, Plasticiser, stabiliser, metathesis, Polystyrene, Polyethene,Polyacrylonitrile, Polymethylmethacrylate, Polybutadiene, Polycarbonates, Polyurethanes, Nylon(6:6 and 6:10), Poly-sulphone.

Details of Discipline Specific Elective (DSE) courses

Course Code	Name of the course	Credits T- Theory Credits P- Practical Credits
Chemistry DSE-3	Transition Metal Clusters-Introduction and Applications	T=2 P=2
Chemistry DSE-4	Advanced Analytical Techniques for Inorganic Compounds	T=2 P=2
Chemistry DSE-7	Advanced Stereochemistry	T=2 P=2
Chemistry DSE-8	Reactive Intermediates of Organic Chemistry	T=2 P=2
Chemistry DSE-12	Interfacial Electrochemistry	T=2 P=2
Chemistry DSE-13	Fundamentals of Solid-State and Materials Chemistry	T=2 P=2
Chemistry DSE-14	Fundamentals of Solid-State and Materials Chemistry	T=2 P=2

POLYMER SCIENCE

COURSES OFFERED BY DEPARTMENT OF CHEMISTRY

Category I

Polymer Science Courses for Undergraduate Programme of Study with Polymer Science as a Single Core Discipline

(B.Sc. Honours in Polymer Science in four years)

STRUCTURE OF VII-VIII SEMESTER

Semester	Discipline specific Core	Elective DSE	GE	Project	AEC	VAC	Total Credit
VII	**Specialty Polymers** (2T+2P)	3 DSE (4) or 2DSE (4)+GE (4) Or 1DSE(4)+2 GE (4)		Project/ Internship/ Technical Report/ Project (6)			22
VIII	**Paints, Coatings, and Adhesive** (2T+2P)	3 DSE (4) or 2 DSE (4)+GE (4) Or 1 DSE(4)+2 GE (4)		Project/ Internship/ Technical Report/ Project (6)			22

A student who pursues undergraduate programme with Polymer Science as single core discipline is offered the following courses:

COURSES OFFERED UNDER B.Sc. (H) POLYMER SCIENCE PROGRAMME

COURSE CODE	NAME OF THE COURSE	CREDITS T=Theory Credits P=Practical Credits
DSE: Paper 16	Wire and Cable Technology	T=2, P=2

DSE: Paper 17	Polymers in Sports and Footwear Technology	T=2, P=2
DSE: Paper 18	Polymeric Membrane	T=2, P=2
DSE: Paper 19	Polymer Foam Technology	T=2, P=2

***DSE: Paper 1 to DSE: Paper 7 will be offered in odd semesters & DSE: Paper 8 to DSE: Paper 14 will be offered in even semesters.**

****DSE: Paper 15 is compulsory for all the students who want to pursue VII and VIII semesters. It will be offered in both VI and VII semesters.**

DSE 16,17 will be offered in VII,whileand 18,19 wil be in VIII semester

Details of Generic Elective (GE) Courses

GENERIC ELECTIVES COURSES (GE)– (4 credits each) –offered for other Departments

COURSE CODE	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
GE: Paper 7	Polymer in Toady's Life	T=2, P=2
GE: Paper 8	Sustainability and Environment	T=3, P=1

SEMESTER-VII

DISCIPLINE SPECIFIC COURSES (DSC-19)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
SpecialtyPolymers	4	2	0	2	12^{Th} with PCM	---

COURSE OBJECTIVES:

1. To study basic concepts of speciality polymers including temperature and fire-resistant and high-performance polymers.
2. To learn about applications of speciality polymers

LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Understand the chemistry for preparation, properties and applications of speciality polymers
2. To analyze the properties of specialty polymers for specific applications such as aerospace, telecommunication, biomedical, defense etc.

THEORY: (30 Hours)

UNIT 1: PREPARATION, PROPERTIES AND APPLICATIONS (15 Hours)

Introduction to engineering/speciality polymers, high temperature and fire-resistant polymers, preparation, properties and applications of the following polymers:

- Polycarbonate (PC)
- Poly(ether ether ketone) (PEEK) and poly(ether-ketone) (PEK)
- Sulphur based polymers (Polysulphone and polyphenylenesulfide)
- Aromatic polyamides, polyamide-imide resins (PAI) and polyimide resins
- Polyacetals
- Polyphenylene oxide (PPO)
- Silicones and polyphosphazenes

UNIT 2: RECENT ADVANCES IN SPECIALITY POLYMERS (5 Hours)

High performance polymer blends and composites, dendrimers, self-healing polymers

UNIT 3: LIQUID CRYSTAL POLYMERS (5 Hours)

Introduction, chemistry of liquid crystal polymerization, synthesis, properties, characteristics of liquid crystal polymers Polyimide, polyamide (Kevlar, Nomax etc.) and polyester-amide based.

UNIT 4: THEMOSETTING POLYMERS (5 Hours)

High performance thermosetting resins such as epoxides, polybenzoxazine etc.

PRACTICALS: **(60 Hours)**

- Synthesis thiokol rubber and tested its thermal stability
- Synthesis of heat resistant polymers and determine their thermal stability.
- Preparation of high-performance composites [(variation in dispersed phase/matrix/coupling agent) like epoxy-kevlar composite]
- Ageing effect of solvents on mechanical properties of polymers.
- Investigation of performance properties of speciality polymers/composites such as thermal stability and fire resistance.
- Determine the acid value of Nylon 6-10
- Characterization of commercially available speciality polymer samples.
- Preparation of polyethylene tetrasulfide and analysis by chemical methods.
- Determine the dielectric properties (dielectric strength and electrical resistance).

REFERENCES:

1. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
2. Dyson R. W., (1990) Engg. Plastics, Blackie, Chapman and Hall.
3. Mohammad, F., (2013) Specialty Polymers: Materials and Applications, I.K. International Publishing House Pvt. Ltd.
4. Fink, J. K. (2014). High performance polymers, William Andrew.
5. Gupta, R. K. (2023),Specialty Polymers: Fundamentals, Properties, Applications and Advances, Taylor & Francis Ltd.

ADDITIONAL RESOURCES:

1. Seymour R.B., Kirshenbaum G.S., (1986) High Performance Polymers: their origin and development, Springer.
2. James E. Mark University of Cincinnati., Polymer data hand book, oxford university press (2013).
3. J. Scheirs, Modern Fluoropolymers:High performance polymers, Wiley Inter science (1997)

ASSESSMENT METHODS:

All the examiniations and assement methods shall be in the line with the University of Delhi guidelinceissused from time to time

KEYWORDS:

Polysulfones, Polyaniline, PEEK, Smart hydrogels, Polycarbonate

SEMESTER-VIII

DISCIPLINE SPECIFIC CORE (DSC-20)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Paints, Coatings, and Adhesive	**4**	**2**	**0**	**2**	**12Th with PCM**	**---**

COURSE OBJECTIVES:

1. To learn about of basics of paints, coatings and adhesive technology and their applications
2. To gain knowledge of formulations of various types of paints, coatings and adhesives

LEARNING OUTCOMES:

After studying this paper, students will be able to

1. Make formulations of various types of paints, coatings and adhesives for desired applications
2. Evaluate quality assessment of paints, coatings and adhesives
3. Understand the challenges and scope of paints, coatings and adhesives industry

THEORY: (30 Hours)

UNIT 1: INTRODUCTION TO PAINTS, COATINGS AND ADHESIVES (5Hours)

General information about paint, paint composition, types of paints: wall, industrial, automobile, Corrosion resistance and flame retardants.Function and properties of paints, Types of adhesives: structural, elastomeric and pseudo plastic

Definition and importance of coating.challenges and future scope of paints, coatings and adhesives industry

UNIT 2: PREPARATION OF PAINTS, COATINGS AND ADHESIVES (10 Hours)

Preparation and compounding ingredients of paints, coatings and adhesives.Formulations, selection and water solubility, manufacturing and uses of paints, coatings (manufacture, criteria and type), adhesive (manufacturing of structural and elastomeric), manufacturing equipment's: high-speed mixers, mill (vertical, horizontal, continuous, sand mill and ball mill)

UNIT 3: COATING OPERATIONS (7 Hours)

Coating operations: brush, roller, both side roller, spray (manual/airless/air guns), dip coating (advantages & limitations), flow coating

UNIT 4: TESTING OF PAINTS COATINGS AND ADHESIVES (8 Hours)

Color and appearance, adhesion, scratch resistance, chemical resistance, wet ability, Thickness, Hardness, weathering, abrasion resistance, viscosity, UV resistance, corrosion resistance etc.,

PRACTICALS: **(60 Hours)**

- Prepare paints (water and solvent-based) and determine the physical properties. i.e. drying time, spreadability, solid content.
- Evaluate adhesive strength by peel test method.
- Prepare adhesive of different formulations.
- Measure the wettability/flowability of adhesives.
- Measure the resin/paint viscosity by Ford cup 4 and Brookfield viscometer.
- Test the film hardness of a coated adhesive film.
- Measure the scratch resistance of painted films.
- Calculate weight percent of paint in a painted film.
- Analyze humidity content of painted films.
- Analysis of paints film by pencil hardness test
- Preparation of coatings by different solvents and medium
- Determination of color, drying time, non -volatile content of coatings.
- Analyse electrical resistance, chemical resistance, durability and thermal resistance of adhesive films.

ESSENTIAL/RECOMMENDED READINGS

1. Morgan W.M., (2000) Outline of Paint Technology, CBS Publisher.
2. StoyeD.,andW.Freitag, (2008) Paints, Coatings and Solvents, Wiley-VCH.
3. Talbert R., (2008) Paints Technology Handbook, CRC Press.
4. Pocius A.V. (2021) Adhesion and Adhesives Technology, Hanser-Verlag

ADDITIONAL RESOURCES:

1. Ryntz R.A., Yaneff P.V., (2003) Coatings of polymers and plastics, Marcel Dekker.
2. Mittal K.L., (2003) Adhesion aspects of polymeric coatings, VSP.
3. Kondekar N.R., A window to paints and coatings technology by colour publications Pvt. Ltd.
4. Arthur A. Tracton.(2006),Coatings Technology: Fundamentals, Testing, and Processing, Taylor and Francis.
5. Board, N. R. (2023). Modern technology of paints, varnishes & lacquers. Asia Pacific Business Press Inc.

ASSESSMENT METHODS:

All the examiniations and assement methods shall be in the line with the University of Delhi gidelinceissused from time to time

KEYWORDS:

Structural adhesives, Wettability, Dip coating, Paints, Surface treatments

DISCIPLINE SPECIFIC ELECTIVE (DSE-16)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Wire and Cable Technology	**4**	**2**	**0**	**2**	**12Th with PCM/PCB**	---

COURSE OBJECTIVES:
The Learning Objectives of this course are as follows:

1. To familiarize with the selection criteria of materials for cable
2. To acquire knowledge of insulation thermal and mechanical properties of cable materials

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

1. Understand the basic concepts materials used in cable industries
2. Develop the understanding of the properties and applications of cable materials.

SYLLABUS OF DSE 16

THEORY: **(30 Hours)**

UNIT 1: INTRODUCTION **(5 Hours)**

Introduction to Insulator, semiconductor and conductor, classification wire and cables (eg. Electric, telecommunication etc.), cable characteristics.

UNIT 2: PROPERTIES OF CABLE INSULATING MATERIALS **(10 Hours)**

i) Electrical: Volume and surface resistivity, break down voltage, dielectric constant, dielectric loss etc.
ii) Thermal: Heat resistance, permissible temperature, effect of overloading on the life of electrical appliances and thermal conductivity
iii) Chemical: Solubility, chemical resistance, weatherability
iv) Mechanical and physical: Mechanical strength, porosity, density, brittleness, mouldability.
v) Factors affecting the electrical, thermal, chemical and mechanical properties of cable insulating materials. Selection of cable insulating materials

UNIT 3: POLYMERS FOR CABLE **(10 Hours)**

Polymers for cable insulation and sheathing (eg. CM, CSM, HDPE, LDPE, PVC, NBR, PTFE, EPDM, EVA, EMA etc.)

UNIT 4: MANUFACTURING OF CABLE **(5 Hours)**

Basic techniques, Extrussion, wire extrusion, Multy wire extrusion.

PRACTICALS: **(60 Hours)**

- Analysis of the thermal stability of cable material.
- Determination of the volume and surface resistivity of cable material.
- Chemical identification of the cable insulating materials
- Determination of fire resistance and smoke density of cable insulating materials.
- Evaluate weatherability of cable materials.
- Determination of mechanical strength (tensile, compressive, elongation, low temperature flexibility (to check ASTM) and hardness), and density of cable materials.
- Manufacturing of wire and cables.
- Determination of limiting oxygen index (LOI) of wire and cable materials.
- Determination of K-value of PVC.
- Industrial visitof cable industries for exposure to instruments and working.

ESSENTIAL/RECOMMENDED READINGS

1. Cousins K., (2000) Polymers for wire and cables- changes within an industry, SmithersRapra Publishing.
2. Black R.M., (1983) The History of Electric wire and Cables, Peter Peregrinus Ltd.

ADDITIONAL RESOURCES:

1. Martin J.M., Smith W.K., (2007) Handbook of Rubber Technology, CBS Publishers.
2. Ganguli, S. K., & Kohli, V. (2016). Power cable technology. CRC Press.

ASSESSMENT METHODS:

All the examiniations and assement methods shall be in the line with the University of Delhi gidelinceissused from time to time

KEYWORDS:

Mechanical strength, thermal insulation, weatherability, Polyvinyl chloride

DISCIPLINE SPECIFIC ELECTIVE (DSE-17)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMERS IN SPORTS AND FOOTWEAR TECHNOLOGY	4	2	0	2	12Th with PCM/PCB	---

COURSE OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To impart knowledge of the basic concepts of raw material and its use in manufacturing of sports and footwear.
2. To learn design and design criteria of sports and footwear

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

1. Apply the knowledge of various type of polymers used in footwear manufacturing
2. Analyse the soling and its material requirements

SYLLABUS OF DSE 17

THEORY: (30Hours)

UNIT 1: SHOE SOLES (10Hours)

Soling requirements, soling materials, compounding and processing. Individual soling compounding-PVC, thermoplastic rubber, polyurethane, ethylene vinyl acetate, etc.

UNIT 2: ADHESIVES FOR SHOE (10 Hours)

Soling adhesives and types of adhesives, adhesion principle, adhesive selections, Heel covering; sole attaching, neoprene, PU, hot melt and liquid curing adhesives, adhesion problems. Coated fabrics: PVC, PU coated fabric.

UNIT 3: SOLES MATERIALS (5 Hours)

Molded and pre fabricated units, individual solings – rubbers, vulcanized rubbers, nylons, polyesters, PVC, thermoplastic rubbers, PU, EVA.

UNIT 4: PROCESSING (5 Hours)

Injection moulding, sponge moulding, direct molded shoes, thermoplastic moulding, polyurethane injection moulding, insert moulding, HF flow moulding.

PRACTICALS: (60Hours)

- Selection and identification of materials for sports equipment (tennis/badminton racket, football, tennis ball, cricket ball etc.)
- Determination of bonding strength of sole.
- Preparation and testing of shoe sole by compression molding.
- Testing of shoe components for different properties such as compressive strength, tensile strength, compression set, shore A etc.
- Estimate tear strength and abrasion resistance of a sole.
- Prepare different compounded sheets of EVA.
- Determine low temperature flexibility of shoe materials.
- Prepare the sponge sole and calculate its specific gravity.
- Prepare PU adhesive for sole bonding and determine the peel strength.
- Estimate out cold flexibility of sport goods
- Demonstration of design aspects of different footwear.
- Industrial visit for exposure to instruments and working.

ESSENTIAL/RECOMMENDED READINGS

1. Martin J.M., Smith W.K., (2007) HandBook of Rubber Technology, CBS Publisher.
2. Harvey A.J., (1982) Footwear Materials and Process Technology, A LASRA publication.
3. Cohn, W.E., (1969) Modern Footwear Materials & Process, Fairchild Publications.
4. Luximon, A. (Ed.). (2021). Handbook of footwere design and manufacture. Woodhead Publishing.

SUGGESTIVE READINGS

1. Venkatappaiah, B. (1997). Introduction to Modern Footwear Technology. B. Sita.
2. S SMuthu, (2020) Leather and Footwear sustainability, Springer.

ASSESSMENT METHODS:

All the examiniations and assement methods shall be in the line with the University of Delhi gidelinceissused from time to time

KEYWORDS:

Compounding, Shoe adhesives, Polyurethane, fabrication of sole.

DISCIPLINE SPECIFIC ELECTIVE(DSE-18)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Polymeric Membrane	4	2	0	2	12^{Th} with PCM/PCB	---

COURSE OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To apprise students with the concept of polymer-based membrane along with their properties and application in water purification, electro dialysis, reverse osmosis and proton conduction.
2. To impart knowledge of synthesis, device fabrication and application of membranes
3. Testing of different polymeric membranes for ion exchange capacity, electrical conductivity and life cycle etc.

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

1. Acquire knowledge about membrane and their preparation.
2. Apply the use polymer membranes for resolving environmental hazards.
3. Develop skills to select different type of polymeric membranes for different type of separations.
4. Use appropriate methods to reduce membrane fouling.

SYLLABUS OF DSE-18

THEORY: (30 Hours)

UNIT 1: INTRODUCTION (5Hours)

Basics of polymer membrane, classifications of membrane: porous vs. non-porous membranes, Charged and neutral membranes,electrical double layer theory, scale-up and commercialization challenges, Policy, regulation, and sustainability aspects

UNIT 2:FABRICATION TECHNIQUES (10Hours)

Polymer used in membrane: PE, PET, PS, biopolymers, etc. Phase inversion techniques, Non-solvent and thermal, Electrospinning and nanofiber membranes, Interfacial polymerization, solvent casting method, and Surface modifications of membrane for enhanced performance

UNIT 3:PROPERTIES AND TESTING (7Hours)

Properties of membrane: mechanical, chemical, permeability, selectivity, flux, dimension, morphology, permeability and selectivity measurements, thermal properties (DSC and TGA), fouling resistance and stability evaluations,

UNIT 4: APPLICATIONS (8 Hours)

Water treatment**:** Reverse osmosis, Desalination and water treatment,

Gas separation**:** Carbon dioxide capture, oxygen enrichment, hydrogen purification.

Energy applications**:** Proton exchange membranes for fuel cells and Batteries

Biomedical applications**:** Hemodialysis membranes, and drug delivery systems

PRACTICALS: (60Hours)

- Prepare a membrane by i) casting ii) analyse its morphology
- Preparation of membrane for Ultrafiltration using Phase Inversion and test its permeability
- Fabricate a membrane by interfacial polymerisation and study its condition
- Determine the ion exchange capacity of a membrane using titration method
- Evaluate the sieving nature of a laboratory prepared polymer membrane
- Evaluate the swelling index and percentage porosity of representative membrane
- Determine the performance and fouling nature of a standard membrane
- Demonstrate the decontamination of polluted water after using membrane
- Evaluate the proton conducting of a standard membrane.

ESSENTIAL/RECOMMENDED READINGS

1. Winston W. S. Ho, Sirkar K. K., (1992), Membrane handbook, Springer.
2. Baker R. W., (2012) Membrane Technology and Applications, John Wiley and Sons.
3. Mulder M., (1996) Basic Principles of Membrane Technology, Springer.
4. Batrinescu, G., Constantin, L. A., Cuciureanu, A., & Constantin, M. A. (2016). Conductive polymer-based membranes, Intehopen Ltd.
5. Mahmoud A. A., (2024) Polymer Membrane, De Gruyter

SUGGESTIVE READINGS

1. Wang, L. K., Chen, J. P., Hung, Y. T., & Shammas, N. K. (Eds.). (2008). Membrane and desalination technologies (Vol. 13). Springer Science, Business Media, LLC.
2. Porter, M. C. (1989). Handbook of industrial membrane technology.US Department of Energy.

ASSESSMENT METHODS:

All the examiniations and assement methods shall be in the line with the University of Delhi gidelinceissused from time to time

KEYWORDS:

Neutral membranes, Fabrication,Electrospinning, Standard membrane, Fuel cells

DESCIPILNE SPACIFIC ELECTIVE COURSES (DSE-19)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMER FOAM TECHNOLOGY	**4**	**2**	**0**	**2**	**12Th with PCM/PCB**	**---**

COURSE OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To learn about the raw materials of foams.
2. Understand the fundamentals of polymer foam technology.
3. Learn about different types of polymer foams and their properties.
4. Study foam formation mechanisms and processing techniques.

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

1. Analyse the building blocks of polyurethanes.
2. Justify the applications of polymer foams in various industries.
3. Understand the effect of the chemical composition of polyurethane foam on properties.

SYLLABUS OF DSE-19

THEORY: (30Hours)

UNIT 1: INTRODUCTION OF FOAMS (7Hours)

Basics and classification of polymer foams. Raw materials, types of foam: Nitrile rubber, Natural rubber latex, Silicone, polyurethane. polystyrene. polyethylene, polypropylene, rebondfoams,etc.

UNIT 2: MANUFACTURING OF FOAM (8Hours)

Foam Formation Mechanisms: Nucleation and growth of bubbles. Foam stabilization and destabilization.

Foam Processing Techniques:Batch foaming, Casting, Spray, continuous foaming, Reaction injection molding of foams and extrusion process.

UNIT 3: PROPERTIES (8Hours)

Polymer Foam Properties: Density, Mechanical properties (compression strength, tensile strength, compression set, low temperature flexibility). Thermal properties(thermal conductivity, etc.). Acoustic properties (sound absorption, etc.).

UNIT 4: APPLICATIONS (7Hours)

Cushioning and packaging. Insulation and energy efficiency. Automotive and aerospace applications. Medical devices and healthcare applications.

PRACTICALS: (60 Hours)

- Preparation of nitrile rubber foam.
- Preparation of expanded polystyrene foam.
- To determine the thermal insulation of nitrile rubber foam.
- Testing of nitrile rubber foams (density, Compressive strength, porosity)
- Preparation of Flexible/Rigid PU foam by RIM.
- Preparation of Flexible PU foam by Molding.
- Testing of foam for handloom and automobile applications.
- Determination of physio-Mechanical properties of commercial polymeric foams (Impact, compression, Tear etc.)

ESSENTIAL/RECOMMENDED READINGS

1. Mills, N. J. (1993). Handbook of polymeric foams and foam technology: D. Klempner and KC Frisch (eds) Carl Hanser Verlag.
2. Oertel G., (1993), Polyurethane Handbook, Hanser Publishers; 2Rev Ed Edition.
3. D.Klempner, V.Sendijarevic,(2024) Polymeric Foams and Foam Technology, Hanser Publisher.

SUGGESTIVE READINGS

1. Walker, B. M., & Rader, C. P. (Eds.). (1979). Handbook of thermoplastic elastomers (pp. 115-205). New York: Van Nostrand Reinhold.
2. Elastomers, T. (1987). A Comprehensive Review, edited by NR Legge, G. Holden, and HE Schroeder.
3. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.

ASSESSMENT METHODS:

All the examiniations and assement methods shall be in the line with the University of Delhi gidelinceissused from time to time

KEYWORDS:

Compressive strength, Thermal properties, Cushioning, Open cell foam.

GENERIC ELECTIVE COURSES (GE-07)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Polymer in Toady's Life	4	2	0	2	12[Th]	---

COURSE OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To give an over view about the use of polymer in current lifestyle
2. The course is designed to provide comprehensive knowledge to the students regarding importance of polymer and its impact in life and the environment.
3. The course is designed to make students aware of the problems due to polymer and their solution.

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

1. understand the importance of polymers in daily life and society
2. learn problems associated with polymers and solutions

SYLLABUS OF GE-07

THEORY: **(30Hours)**

UNIT 1: POLYMERS **(7Hours)**

Introduction to polymers, properties, and resources polymer.
Classification of polymer, Brief details about Natural and Synthetic polymer(cellulose, starch, PE PP and PS)

UNIT 2:PREPRATION OF POLYMERS **(8Hours)**

Polymerizations, different method of polymerizations, Modification of polymer, Polymercomposit.

UNIT 3: COMMON USE OF POLYMER **(8Hours)**

Polymer is Packaging
Polymer in Textile
Polymers in civil and structural applications
Polymers in electronic devices

UNIT 4: POLYMER AND ENVIRONMENT (7Hours)

Impact of polymer on environment and their solution
Rules and Regulations of use of plastic and its management: Indian Perspective
Reuse of plastics

PRACTICALS: (60Hours)

- Isolate the cellulose from sugarcane bagasse and identify their properties
- Identify the functional group of polymer by chemical methods and spectroscopic method
- Prepare a packaging film and determine its thickness and hardness
- Separate the polymer from flexible packaging film and report the yield
- Demonstrates the degradation effect of plastic in polymers
- Determine the biocompatibility of plastic items.

ESSENTIAL/RECOMMENDED READINGS

1. Fred W. Billmeyer Jr., (1984) Textbook of Polymer Science, Wiley-lnterscience Publication John Wiley & Sons
2. Joel R. Fried(2014), Polymer Science and Technology" Prentice Hall.

ADDITIONAL RESOURCES

1. Charles E. Carraher Jr.,(2017) Introduction to Polymer Chemistry, CRC Press.
2. O. Olatunji,(2024) Natural Polymers: Industry Techniques and Applications, Springer; 1st edition.

ASSESSMENT METHODS:

All the examiniations and assement methods shall be in the line with the University of Delhi gidelinceissused from time to time

KEYWORDS:

Synthetic polymer, Polymerizations, Natural polymers, cellulose.

GENERIC ELECTIVE COURSE (GE-08)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Sustainability and Environment	4	3	0	1	12Th	---

COURSE OBJECTIVES:

The Learning Objectives of this course are as follows:

1. To evaluate the environmental impact of products or services using life cycle assessment.
2. To manage Intellectual Property portfolio to enhance the value of the firm.
3. To apply sustainable practices in daily life (reduce, reuse, recycle).
4. To advocate for environmental policies and practices.
5. To develop a sense of responsibility for environmental conservation.

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

1. Analyze environmental issues and develop solutions.
2. Apply sustainability principles in various industries (business, government, non-profit).
3. Develop expertise in environmental management, policy, or conservation.

THEORY: (45Hours)

UNIT 1: CONCEPT OF SUSTAINABILITY (10Hours)

Importance and objective of Sustainability.Different aspects of sustainability: Energy, material, society and their correlation. Evolution of the concept of ESG (environment, social and governance). Sustainability and Net Zero concept. Concept of Life Cycle Analysis.

UNIT 2: RULES, REGULATION, AND POLICIES RELATED TO SUSTAINABILI

(10Hours)

Importance of Rules, regulations and policies in maintaining sustainability, Policies related to sustainability in India, Sustainability Policies in Global scenario, India's Policy Landscape and its Business Implications

UNIT 3: APPROACH TOWARDS SUSTAINABILITY (15Hours)

Cocept of Circular Economy - Challenges, Opportunities and FutureProspects, Renewable energy and optimization of energy usage Socio-cultural dimensions for sustainable approach, The business case studies for sustainability

UNIT 4: RESORCE MANAGEMENT (10Hours)

Natural resource and its management, Energy managements, material recycling for used polymers.

PRACTICALS: (30Hours)

1. Study the effect of polymer degradation on soil and water i.e. pH, porosity, water retaining capacity.
2. Estimate the waste generation during preparation of polymers
3. Demonstrate the chemical recycling of used plastic sample PVC pipe
4. Prepare a biodegradable film for packaging of edible items
5. Submit a assignment on Indian regulation on dumping of plastic
6. Calculate the recycling efficiency of plastic bottles of laboratory chemicals.
7. Demonstrate a small polymer processing plant with “Net Zero Concept”.

ESSENTIAL/RECOMMENDED READINGS

1. Wilson, G., Furniss, P., &Kimbowa, R. (Eds.). (2010). Environment, Development, and Sustainability: perspectives and cases from around the world. Open University Press.
2. Mulligan, M. (2017). Introduction to sustainability. Taylor & Francis.
3. Pugh, C. (2014). Sustainability the environment and urbanisation. Routledge.

ADDITIONAL RESOURCES:

1. Adams, B. (2008). Green development: Environment and sustainability in a developing world. Routledge.
2. Thangavel, P., & Sridevi, G. (2016). Environmental sustainability. Springer, India, Private.
3. Barr, S. (2016). Environment and society: Sustainability, policy and the citizen. Routledge.

ASSESSMENT METHODS:

All the examiniations and assement methods shall be in the line with the University of Delhi gidelinceissused from time to time

KEYWORDS:

Energy managements, Circular Economy, Life Cycle Analysis, Natural resource, Sustainability.

B.Sc. (Analytical Chemistry)
(Chemistry Component)

Semester-wise Distribution of DSC, DSE and GE Courses

Semester	Course type	NAME OF THE COURSE	Credits
VII	DSC-19	ADVANCED INSTRUMENTAL METHODS 1	T=3; P=1
	DSE-6	MATERIALS SCIENCE	T=2; P=2
	DSE-7	COMPUTATIONAL METHODS AND MOLECULAR MODELLING	T=2; P=2
	DSE-8*	INTRODUCTORY INTERFACIAL ELECTROCHEMISTRY	T=2; P=2
	GE	GREEN ENERGY SOLUTIONS	T=2; P=2
VIII	DSC-20	ADVANCED INSTRUMENTAL METHODS II	T=3; P=1
	DSE-9	CHEMINFORMATICS	T=2; P=2
	DSE-10	CHEMICAL PATENT ANALYTICS & IP STRATEGY	T=2; P=2
	DSE-11*	FUNDAMENTALS OF MEDICINAL CHEMISTRY	T=2; P=2
	GE	INDUSTRIAL POLLUTION-IMPACTS & REMIDIES	T=2; P=2

NOTE: * For syllabus content of Discipline Specific Elective-8 (DSE-8)"Introductory Interfacial Electrochemistry" and Discipline Specific Elective-11 (DSE-11) "Fundamentals of Medicinal Chemistry" refer to DSE syllabus of B.Sc. (Physical Sciences) DSE-18 PS and DSE-20 respectively.

SEMESTER VII

DISCIPLINE SPECIFIC CORE COURSE-19

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
ADVANCED INSTRUMENTAL METHODS 1	4	3	0	1	12^{th} Class: Physics, Chemistry, Mathematics	-

Course Objectives:

- To introduce the students to advanced techniques in molecular structure elucidation using instrumental methods.
- To provide theoretical and practical knowledge of Mass Spectrometry and Nuclear Magnetic Resonance Spectroscopy.
- To develop skills for interpreting spectral data and deducing the structure of unknown compounds using a combination of techniques.

Learning Outcomes:

By the end of this course, students will be able to learn:

- Interpret and analyze mass spectra to identify molecular weights and fragment patterns.
- Understand and apply 1D and 2D NMR techniques in structural elucidation.
- Integrate data from UV-Vis, IR, NMR, and MS to deduce complex molecular structures.
- Perform hands-on experiments using spectroscopy instrumentation and software tools for spectral interpretation.

SYLLABUS OF DSC- 19

THEORY COMPONENT

UNIT 1: Mass Spectrometry **(15 Hours)**

Basic principles: Instrumentation: Sample Inlet system,

Ionization techniques; (EI, CI, ESI, MALDI, API, FAB), Mass analysers: Quadrupole, Time-of-Flight (TOF), Magnetic Sector, Radius of ion, Orbitrap, FT-ICR. Positive fragment ions peak, metastable peak, isotopic mass peaks, Recognition of M^+ Peak, singly, doubly and multiply charged ions. General fragmentation rules and fragmentation of different classes of compounds, factors governing general fragmentation processes, Mc Lafferty Rearrangement and Ortho effect, Nitrogen rule, Rule 13.

Applications: High-resolution mass spectrometry (HRMS), isotope patterns, exact mass, tandem MS (MS/MS). Use known compounds for spectrum-based analysis: **Acetophenone** (Analyze fragmentation and base peak formation), **n-Butylamine** (Use nitrogen rule and α-cleavage pathways), **Toluene** (Observe loss of CH_3 and formation of tropylium ion (m/z 91), **Methionine (amino acid)**: Apply ESI and analyze isotope peaks for sulfur.

UNIT 2: Advanced NMR Spectroscopy (15 Hours)

^{13}C NMR Spectroscopy: Natural abundance, resolution and multiplicity of ^{13}C NMR, ^{1}H decoupling, noise decoupling, broad band decoupling, Deuterium, fluorine coupling; NOE signal enhancement, off-resonance, DEPT (Distortionless Enhancement by Polarization Transfer): DEPT-45, DEPT-90, DEPT-135 (Identify CH_3, CH_2, CH, and quaternary carbons in ethylbenzene.

Two-Dimensional Nuclear Magnetic Resonance Spectroscopy (2D NMR): Basic introduction of 2D NMR, The spin-echo experiment, multi-pulse NMR, Homonuclear correlation experiments (COSY), Heteronuclear correlation (HETCOR, HMQC, HSQC), NOE experiments (NOESY, HOESY, ROESY), and INADEQUATE, Exchange Spectroscopy (ESXY)

Variable Temperature and Dynamic NMR: Study of conformational changes and fluxional behavior, Coalescence temperature and line shape analysis, Arrhenius/Eyring plots for rate constant determination, **VT NMR** of N,N-dimethylformamide (DMF): Observe restricted rotation of N–CH_3 groups at low temperatures, **Dynamic NMR** of cyclohexane: Detect chair inversion and estimate activation barrier.

Solid-State NMR (Basics Only), Magic Angle Spinning (MAS), Cross-Polarization (CP-MAS).

UNIT 3: Structure Elucidation (7 Hours)

Structure elucidation of complex organic compounds based on 1H-NMR, 13 C-NMR, 2D NMR, IR, UV, and MS spectral data: Functional group identification, fragment identification, connectivity, symmetry, diastereotopicity, shielding/deshielding effects, spin-spin coupling, exchangeable protons. Contour plot reading and identification of interactions.

UNIT 4: Quantitative NMR (8 Hours)

Quantitative NMR (qNMR): Principles of quantitation using NMR, proportionality of signal intensity and number of nuclei, factors affecting accuracy: relaxation time (T_1), pulse angle, acquisition time. Applications of qNMR: Purity determination, quantification of mixture, stability study, degradation/reaction/process monitoring, intermediate identification, etc,

Use of spectral databases (NIST, SDBS, ChemSpider), Introduction to software: MestReNova, Delta JEOL, ACD/NMR, Bruker TopSpin, ChemDraw for spectra simulation.

PRACTICAL COMPONENT **(30 Hours)**

1. Identify the possible fragment ions for the following classes of compounds (Provide the mss spectra and discuss the fragmentation processes)
    a) Alkyl-substituted benzenes
    b) Phenols
    c) Aldehydes and ketones
    d) Esters
    e) Amines
    f) Nitro compounds
    g) Alkyl halides
2. Process the given FID files of NMR spectra using any NMR processing software, and identify the compound (Provide the molecular formula)
3. Record the NMR spectra of simple organic compounds, simulate the NMR spectra of same compounds using ACD/NMR, ChemDraw, MestReNova or any other software, and compare the results.
4. Elucidate the structure of organic compounds using UV-Vis, MS, IR, ^{1}H NMR and ^{13}C NMR (Provide the spectral data).
5. Interpret 2D NMR spectra of organic molecules (provide the spectra).
6. Estimate the percentage of purity or percentage of isomers using the given ^{1}H NMR spectrum.
7. Analyze ^{13}C CP-MAS data of polymers or crystalline drugs (Identify carbon environments and discuss applications)

RECOMMENDED/ESSENTIAL TEXTBOOKS AND REFERENCES

Theory:

1. Pavia, D. L., Lampman, G. M., Kriz, G. S., & Vyvyan, J. R., Introduction to Spectroscopy (5th Edition) – Cengage Learning
2. Silverstein, R. M., Webster, F. X., & Kiemle, D. J., Spectrometric Identification of Organic Compounds (7th Edition) – Wiley
3. Williams, D. H., & Fleming, I., Spectroscopic Methods in Organic Chemistry (6th Edition) – McGraw Hill
4. Lambert, J. B., Shurvell, H. F., Lightner, D. A., & Cooks, R. G., Organic Structural Spectroscopy – Pearson
5. Claridge, T. D. W., High-Resolution NMR Techniques in Organic Chemistry – Elsevier

Practicals:

1. Pavia, D. L., Lampman, G. M., Kriz, G. S., Introduction to Organic Laboratory Techniques – Cengage
2. Instrumental manuals and user guides (Bruker, JEOL, Thermo, Agilent etc.)
3. Online Platforms:
    - Spectral Database for Organic Compounds (SDBS)
    - ChemSpider
    - NIST

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE 6

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MATERIAL SCIENCE	4	2	0	2	12^{th} Class: Physics, Chemistry, Mathematics	NIL

Course Objectives:

- Understand the fundamental chemistry behind smart and responsive materials.
- Analyze how external stimuli affect chemical and physical behavior.
- Apply smart material concepts to emerging technologies and real-world applications.
- To provide a scientific understanding of composite materials, including their classification, synthesis, chemical behavior, and analytical characterization.
- To develop hands-on skills in preparing and analyzing composite materials using standard instrumental techniques.

Learning Outcomes

By the end of this course, students will be able to:

1. Define and classify various smart materials based on their responsiveness.
2. Describe the molecular-level mechanisms that govern smart behavior.
3. Analyze real-life applications of smart materials in biomedical, industrial, and environmental domains.
4. Classify different types of composite materials and explain matrix-reinforcement chemistry.
5. Prepare basic polymer composites using hand lay-up methods.
6. Critically assess real-life applications of composite materials in different industries.

THEORY COMPONENT

UNIT 1: Smart Materials (9 hours)

Introduction to Smart Materials - Definitions, history, and importance; Types and classifications; General applications

Molecular Basis of Responsiveness - Stimuli-responsive mechanisms; Molecular interactions and chemical triggers; reversible behaviour

Shape Memory Materials - Alloys (e.g., Nitinol) and shape memory polymers; Mechanistic explanation; Biomedical and structural applications

Thermo- and pH-Responsive Polymers - Polymer behaviour with temperature and pH; LCST and UCST phenomena.
Photo-responsive Materials - Cis-trans isomerization (azobenzene, spiropyran); Photochromism and molecular switches; Smart windows, data storage
Electrochromic and Piezoelectric Materials - Redox-induced optical changes; Electric field-induced mechanical response; Applications in flexible electronics and wearables
Self-Healing Materials - Micro-encapsulation and polymer chemistry; Intrinsic vs extrinsic healing; Aerospace, electronics, and coatings.
Smart Coatings and Textiles - Responsive surfaces; Moisture, temperature, and pollutant-sensitive textiles; Industrial and military applications
Emerging Trends and Future Prospects - 4D printing, adaptive materials, AI-integrated materials; Challenges: cost, scalability, and environmental impact; Career and research opportunities

UNIT 2: Composite Materials (6 hours)
Fundamentals of Composites: Definition and importance of composite materials, Classification: PMC (Polymer Matrix Composites), MMC (Metal Matrix Composites), CMC (Ceramic Matrix Composites), Basic matrix-filler concept, Real-world examples (building materials, bicycles, sports goods)
Reinforcement Interaction & Matrix Chemistry: Molecular bonding between filler and matrix (simplified), Interface chemistry (basic idea of bonding), Types of polymers: Thermosets vs. Thermoplastics, Functional groups in epoxy and polyester (only basic structural features), Role of initiators and crosslinkers
Curing & Composite Preparation Techniques: Curing process and epoxy hardening (with visuals), Coupling agents like silanes, Preparation methods (conceptual only): Hand lay-up, Extrusion, Compression molding, Spray lay-up, Vacuum bagging & autoclave (demonstration-based understanding)

UNIT 3: Biomaterials (9 hours)

Introduction to Biomaterials: Definition and scope of biomaterials, historical development and milestones, classification: metals, ceramics, polymers, composites, and natural biomaterials. Key properties: Biocompatibility, biodegradability, mechanical strength, and surface characteristics.
Biomaterials in Medical Applications
Orthopedic Biomaterials: Metals (titanium, stainless steel, Co-Cr alloys), bioactive ceramics (hydroxyapatite, bioglass), polymer composites for joint replacements and bone grafts.
Cardiovascular Biomaterials: Stents (bare-metal, drug-eluting, bioresorbable), heart valves (mechanical vs. tissue-based), vascular grafts and artificial blood vessels.
Dental Biomaterials: Dental implants (titanium, zirconia), restorative materials (composites, ceramics, amalgams), biodegradable scaffolds for periodontal regeneration.
Biomimetic and Bio-inspired Materials - Learning from nature (e.g., lotus effect, gecko adhesion); Supramolecular chemistry; Applications in tissue scaffolding and robotics, natural vs. synthetic scaffolds (collagen, PLGA, PCL), material used in skin, cartilage, and bone regeneration.

UNIT 4: Characterization Techniques: (6 hours)

Characterization Techniques: FTIR, UV-Vis, CHNS, TGA/DTG, DSC, SEM/EDX

Stability, Surface & Real-World Applications: Degradation under acidic and basic media, Leaching and environmental testing, Surface morphology: Cracks, bonding, fiber-pull, Application case studies:

- Fly-ash/glass fiber composites in buildings
- Carbon fiber in cars/planes
- Bio-composites in packaging/medical uses
- Corrosion-resistant composites in coastal infrastructure

PRACTICAL COMPONENT **(60 Hours)**

1. Thermo-responsive Polymer Gel: Synthesize poly(N-isopropylacrylamide) and demonstrate phase transition at LCST.
2. Shape Memory Wire Demonstration: Heat and recover shape of Nitinol wire.
3. Photochromic Dye Experiment: Use spiropyran or azobenzene-based materials and expose to UV light.
4. pH-Sensitive Color Change: Use anthocyanin extract or pH indicators in polymer films.
5. Electrochromic Device Prototype: Build a simple setup using a viologen-based electrochromic material.
6. Bioinspired Surface: Prepare lotus-leaf-mimicking superhydrophobic surface using candle soot or nanoparticle coatings.
7. Preparation of a Glass-Fiber Reinforced Epoxy Composite: To prepare and understand the hand lay-up method and curing.
8. FTIR Analysis of Uncured vs Cured Epoxy Composite: To study functional group changes during curing, IR peaks (C=O, OH, epoxy ring), crosslinking evidence.
9. Thermal Stability by TGA: To determine the decomposition temperature of the polymer composite, Mass loss curve interpretation.
10. Surface Morphology by SEM (demonstration/image analysis): To observe surface topology, fiber pull-out, cracks, SEM image interpretation.
11. pH and Ion Leaching Test of Composites: To assess chemical stability under acidic/basic media, Leachate analysis using pH/conductivity meter or titration.

RECOMMENDED/ESSENTIAL TEXTBOOKS AND REFERENCES

Theory

1. "Smart Materials and Structures" by M.V. Gandhi and B.S. Thompson
2. "Smart Materials in Structural Health Monitoring, Control and Biomechanics" by Chee K. Tan
3. "Stimuli-Responsive Materials: From Molecules to Nature Mimicking Materials Design" by Qiang Zhao and Tao Xie
4. Selected research articles and review papers (to be provided per topic)
5. K.K. Chawla, *Composite Materials: Science and Engineering*
6. D.D.L. Chung, *Functional Materials: Composites and Hybrid Systems*
7. R.F. Speyer, *Thermal Analysis of Materials*
8. Research Articles from *Polymer Composites*, *Composites Part A*, *Journal of Applied Polymer Science*
9. ASTM/ISO standards for composite testing (optional for PG)

Practicals

1. Smith, B. C. *Infrared Spectral Interpretation: A Systematic Approach*, CRC Press.
2. Silverstein, R. M., et al. *Spectrometric Identification of Organic Compounds*, Wiley
3. Speyer, R. F. *Thermal Analysis of Materials*, Marcel Dekker, 1994.
4. Hatakeyama, H. & Hatakeyama, T. *Thermal Analysis: Fundamentals and Applications to Polymer Science*, Springer.
5. Goldstein, J. I., et al. *Scanning Electron Microscopy and X-ray Microanalysis*, Springer.
6. Skoog, D. A., Holler, F. J., & Crouch, S. R. *Principles of Instrumental Analysis*, Cengage Learning.
7. Sparks, D. L. *Environmental Soil Chemistry*, Academic Press. (For leaching relevance).
8. Callister, W. D., & Rethwisch, D. G. *Materials Science and Engineering Laboratory Manual*, Wiley.

Suggested readings:

1. Ratner, B. D., Hoffman, A. S., Schoen, F. J., & Lemons, J. E. Biomaterials Science: An Introduction to Materials in Medicine (3rd Edition) - Academic Press
2. Park, J., & Lakes, R. S. Biomaterials: An Introduction (3rd Edition) - Springer
3. Williams, D. F. The Biomaterials: Silver Jubilee Compendium - Elsevier
4. Ong, K. L. Orthopedic Biomaterials in Research and Practice - Springer
5. How, T. V., & Black, R. A. Biomaterials and Devices for the Circulatory System – Woodhead
6. Lanza, R., Langer, R., & Vacanti, J. Principles of Tissue Engineering (5th Edition) - Academic Press
7. Al-Shibouri, A. M., & Nimesh, S. Engineering Drug Delivery Systems - Elsevier

Online Resources:

1. National Institute of Biomedical Imaging and Bioengineering: https://www.nibib.nih.gov
2. Materials Today Biomaterials https://www.materialstoday.com/biomaterials

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE 7

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
COMPUTATIONAL METHODS AND MOLECULAR MODELLING	**4**	**2**	**0**	**2**	**12th Class: Physics, Chemistry, Mathematics**	**-**

Course Objectives:

- To make students learn the theoretical background of computational techniques in molecular modelling.
- To give the different flavours of computational chemistry by the end of this course.
- To provide hands-on experience in molecular modelling on various software

Learning Outcomes:

Students will be able to:

- Explain the theoretical background of computational techniques and selective application to various molecular systems
- Compare computational and experimental results and explain deviations.
- Perform Optimization of geometry parameters of a molecule (such as shape, bondlength and bond angle) through the use of software like Chem Sketch and Argus Lab in interesting hands-on exercises.
- Perform analysis of molecular properties using various software

UNIT 1: Introduction (6 hours)

Introduction to computational chemistry: Overview of Classical and Quantum Mechanical Methods (Ab initio, DFT, Semi-empirical, Molecular Mechanics, Molecular Dynamics, and Monte Carlo)

UNIT 2: Potential Energy Surfaces (6 hours)

Intrinsic Reaction Coordinates, Stationary points, Equilibrium points – Local and Global minima, Geometry optimization and energy minimization, the concept of transition state with examples, Hessian matrix

UNIT 3: Molecular Mechanics & Molecular Dynamics (6 hours)

Molecular Mechanics:

Force Fields (A brief explanation of all the terms of a basic force field), parametrising a force field, the basic idea of MM1, MM2, MM3, MM4, MM+, AMBER, BIO+, OPLS.

Molecular Dynamics:

The concept of the periodic box, ensembles (microcanonical, canonical, isothermal – isobaric), steps in a typical MD simulation.

UNIT 4: Huckel Molecular Orbital Theory (12 hours)

Huckel MO with examples: ethene and propenyl systems, Properties calculated – energy, charges, bond order, electronic energies, resonance energies.

Ab-Initio Methods

Antisymmetry principle, Slater determinants, SCF method, Hartree-Fock method.
Basis sets, Basis functions, STOs and GTOs, diffuse and polarization functions. Minimal basis sets

Practicals **(60 hours)**

Any 8 -10 Problems

1. Write the Z-Matrix of a given set of molecules.
2. Carry out geometry optimisation on H_2O, H_2S, H_2Se molecules compare the optimized bond angles and dipole moments from the results obtained. Obtain the ESP-mapped density surfaces and interpret the results obtained with reference to bonding in these molecules.
3. Calculate the energy of the following chemical species and arrange them in order of increasing stability:

   1-hexene, 2-methyl-2-pentene, (E)-3-methyl-2-pentene, (Z)-3-methyl-2-pentene, and 2,3- dimethyl-2-butene in order of increasing stability.

4. Carry out geometry optimisation on the following chemical species and compare the shapes and dipole moments of the molecules:

   1-pentanol, 2-pentanol, 3-pentanol, 2-methyl butan-1-ol, 3-methyl butan-1-ol, 2-methyl butan-2-ol, 2-methyl butan-3-ol and 2,2-dimethyl propanol.

5. Based on the implicit electronic structure calculations, determine the heat of hydrogenation of Propylene.
6. Based on the calculations of enthalapies of the participating chemical species on the optimized geometry of the molecules, calculate the reaction enthalpy at 298K of (a) Steam reforming of methane (b) Haber-Bosch Process
7. Carry out geometry optimisation & Energy calculations on Benzene, Naphthalene, and Anthracene. Obtain Frontier Molecular Orbitals, visualise the Molecular Orbitals of these species, and interpret the results for bonding in these molecules.
8. Compare the gas phase basicities of the methylamines by comparing the enthalpies of the following reactions:

   $BH^+ + NH_3 \rightarrow B + NH_4^+$

   Where B = CH_3NH_2, $(CH_3)_2NH$, $(CH_3)_3N$

9. Based on the results of geometry optimization and energy calculations, determine the enthalpy of isomerization of cis and trans 2-butene.
10. Perform a conformational analysis of butane. Plot the graph between the angle of rotation and the energy of the conformers using spreadsheet software.
11. Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.
12. Calculate the electronic UV/Visible absorption spectrum of Benzene.
13. Calculate the electronic absorption spectra of formaldehyde.
14. Plot the electrostatic potential mapped on electron density for benzene and use it to predict the type of stacking in the crystal structure of benzene dime.

RECOMMENDED/ESSENTIAL TEXTBOOKS AND REFERENCES

Theory:

- Lewars, E. (2003), Computational Chemistry, Kluwer academic Publisher.
- Cramer, C.J. (2004), Essentials of Computational Chemistry, John Wiley & Sons.
- Hinchcliffe, A. (1996), Modelling Molecular Structures, John Wiley & Sons.
- Leach, A.R. (2001), Molecular Modelling, Prentice-Hall.
- House, J.E. (2004), Fundamentals of Quantum Chemistry, 2nd Edition, Elsevier.
- McQuarrie, D.A. (2016), Quantum Chemistry, Viva Books.
- Levine, I. N.; Physical Chemistry, 5th Edition, McGraw –Hill.

Practicals

- https://www.afs.enea.it/software/orca/orca_manual_4_2_1.pdf
- https://dasher.wustl.edu/chem430/software/avogadro/learning-avogadro.pdf
- http://www.arguslab.com/arguslab.com/ArgusLab.html
- https://barrett-group.mcgill.ca/tutorials/Gaussian%20tutorial.pdf
- https://gaussian.com/techsupport/
- https://gaussian.com/man/
- https://gaussian.com/wp-content/uploads/dl/gv6.pdf
- https://dasher.wustl.edu/chem478/software/spartan-manual.pdf
- http://www.mdtutorials.com/gmx/
- https://vina.scripps.edu/manual/

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DISCIPLINE SPECIFIC ELECTIVE 8

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
INTRODUCTORY INTERFACIAL ELECTROCHEMISTRY	4	2	0	2	12^{th} Class: Physics, Chemistry, Mathematics	-

****For syllabus content of Discipline Specific Elective-8: (DSE-8) "Introductory Interfacial Electrochemistry" refer to the syllabus content of DSE-18 PS of B Sc. Physical Sciences Programme.**

GENERIC ELECTIVE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GREEN ENERGY SOLUTIONS	**4**	**2**	**0**	**2**	**12th Class: Physics, Chemistry, Mathematics**	**-**

Course Objectives:

- Introduce core concepts in renewable and non-renewable energy
- Explain the science behind clean energy technologies
- Provide insight into India's current green energy initiatives
- Familiarize students with practical tools, energy efficiency, and storage systems
- Create awareness about policy, innovation, and future career opportunities in energy

Learning Outcomes:

Students will be able to:

- Identify major renewable energy systems and their underlying science
- Estimate solar potential using simulation tools
- Understand India's energy policies, electric mobility plans, and startup innovations
- Apply basic energy audit and comparative assessment techniques
- Participate in group-based exploration and communication of green energy ideas

THEORY:

Unit 1: Energy and the Environment (6 Hours)

- Forms of energy; renewable vs non-renewable
- Fossil fuels: sources, use, and environmental impact
- India's energy consumption profile
- Environmental consequences: air pollution, greenhouse gases, climate change
- Traditional Indian energy practices and their sustainability insights

Unit 2: Solar and Hydrogen Energy (8 Hours)

- Basics of solar energy: photovoltaic effect, solar thermal systems
- Types of solar panels: monocrystalline, polycrystalline (basic comparison)
- Components and layout of a small solar system, perovskite solar cells
- Hydrogen as a fuel: green hydrogen electrolysis, properties, use cases, safety
- Fuel cells: basic working principle and relevance in transportation
- India's solar programs and National Green Hydrogen Mission

Unit 3: Biofuels, Batteries, and Energy Storage (8 Hours)

- Types of biofuels: ethanol, biodiesel, biogas – preparation, chemistry, benefits
- Battery technologies: lead-acid, lithium-ion – structure, function, and applications
- Importance of grid-level storage and stability
- Energy storage methods: pumped hydro, BESS, and battery-integrated solar setups
- Electric Vehicles as mobile storage; Battery swapping and EV charging ecosystem

- India's FAME scheme and emerging EV landscape

Unit 4: Energy Efficiency, Policy, and Innovation (8 Hours)

- Energy-efficient appliances, conservation practices, behavioral changes
- Carbon footprint: meaning, impact, and mitigation
- Life Cycle Analysis (LCA): basic concept and real-life examples
- Key Indian government programs: UJALA, PM-KUSUM, FAME, Green Hydrogen Mission
- Carbon markets and energy pricing (simplified overview)
- Indian startups and innovations in green energy: ReNew, Ather, Log9, Ola Electric

PRACTICALS

Any 8 Activities + 1 Group Project optional

1. Compare visible smoke and residue from different fuel types (wood, kerosene, LPG – demo)
2. Create and test a fruit or salt-water battery
3. Prepare simple biodiesel from vegetable oil (under supervision)
3. Estimate rooftop solar output using MNRE Solar Calculator or RETScreen (guided worksheet)
4. Conduct a home/college room energy audit (appliances, lighting, fan usage)
5. Compare energy-efficient vs conventional appliances (e.g., LED vs CFL)
6. Poster/model or infographic on one major Indian energy initiative or clean-tech startup
7. Survey-based project: public awareness of solar/EVs in your locality
8. Group project + viva presentation on a selected green energy theme

Suggested Readings

- *Energy Resources and Utilization* – K. S. Ramaswamy (Narosa Publishing)
- *Environmental Chemistry and Pollution Control* – S. S. Dara (S. Chand)
- *Renewable Energy and Environment* – Mukesh Khare & R. K. Anand (Narendra Publishing)
- Selected articles from *Down to Earth* – Centre for Science and Environment (CSE)
- Government PDFs and online documents from MNRE, FAME India, and UJALA portals

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SEMESTER VIII

DISCIPLINE SPECIFIC CORE COURSE-20

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
ADVANCED INSTRUMENTAL METHODS II	**4**	**3**	**0**	**1**	**12^{th} Class: Physics, Chemistry, Mathematics**	**-**

Course Objectives:

- To provide fundamental and applied knowledge of thermal and surface analytical techniques.
- To enable students to understand the principles and instrumentation of thermal analysis and nanostructure characterization.
- To interpret data from TGA, DTA, DSC, SEM, and TEM for material identification and behavior analysis.

Learning Outcomes:

By the end of the course, students will be able to:

- Understand the principles and instrumentation of thermal analysis (TGA, DTA, DSC).
- Apply thermal techniques to analyze thermal stability, decomposition, and transitions of materials.
- Understand the working, imaging principles, and resolution differences between SEM and TEM.
- Analyze nanoscale morphology, particle size, and surface features using SEM and TEM data.
- Conduct basic data interpretation and material characterization using experimental tools and simulation software.

THEORY:

UNIT 1: Introduction to Thermal Analysis (10 Hours)

Overview of thermal methods: Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC), Classification: Dynamic and Isothermal techniques, Comparative overview: TGA, DTA, DSC, TMA (Thermomechanical Analysis), and DMA (Dynamic Mechanical Analysis), Importance of thermal analysis in materials science, pharmaceuticals, polymers, and food technology, Types of Samples and Sample Handling: Sample forms: powders, solids, films, liquids, Factors affecting thermal behavior: mass, particle size, packing, thermal conductivity, Sample pans: crucible materials (alumina, platinum, aluminum), Calibration and Standardization: Instrument calibration using reference materials (e.g., indium, tin, lead for DSC), Baseline correction, temperature calibration, and sensitivity testing, Importance of reproducibility and blank run procedures, Factors Influencing Thermal Curves: Instrumental parameters: heating rate, gas flow rate, crucible type, Environmental effects: humidity, atmospheric pressure, Interaction with container walls or decomposition gases

UNIT 2: Thermogravimetric Analysis (TGA) (10 Hours)

Thermogravimetric Analysis (TGA) – Basic Concepts, Principle and instrumentation of TGA, Thermogram interpretation: weight loss, multi-step decomposition, Analysis of $CaCO_3$ decomposition, Thermal stability of polymers and metal complexes, Significance of inert (N_2) and oxidative (O_2, air) atmospheres, TGA coupled with **mass spectrometry (TGA-MS)** for evolved gas analysis, TGA-FTIR for gas-phase identification of decomposition product.

UNIT 3: DSC and DTA (10 Hours)

Differential Scanning Calorimetry (DSC) – Basic Concepts, Heat flow vs. temperature curves, Principle and comparison of DTA vs. DSC, Endothermic and exothermic transitions, Determination of melting point, glass transition temperature (Tg), crystallinity, Heat capacity and enthalpy measurements, Phase transition of polyethylene, Crystallinity changes in semicrystalline polymers, Enthalpy of fusion for organic solids, Applications in food additives, drug formulation, and polymer quality control. **Differential Thermal Analysis (DTA)** – Basic Concepts, Principle of differential temperature measurement between sample and reference, Typical DTA curves and interpretation: endothermic/exothermic events, Instrument setup and thermocouple configurations, **Classification of Thermal Techniques**, Dynamic vs. Isothermal methods, Static vs. programmed heating, Importance of heating/cooling rates and sample holder selection.

UNIT 4: Introduction to Nanomaterials and Electron Microscopy (15 Hours)

Basics of nanomaterials: size, surface effects, properties, Introduction to imaging: resolution, contrast, magnification, Electron-material interaction and signal generation, **Scanning Electron Microscopy (SEM):**Working principle and instrumentation of SEM, Secondary electron and backscattered electron imaging, Sample preparation and gold coating, Surface topology, morphology, particle shape analysis, SEM of nanoparticles, corrosion pits, biological materials, **Transmission Electron Microscopy (TEM):** Principle and instrumentation of TEM, Electron diffraction, contrast mechanisms, High-resolution TEM (HRTEM), Sample thinning techniques, TEM images of metal nanoparticles, nanorods, and carbon nanotubes, Crystallite size and lattice fringes.

PRACTICAL COMPONENTS (30 Hours)

1. Thermogravimetric Analysis (TGA) of hydrated salts or polymers. Record weight loss and analyze decomposition steps.
2. DSC analysis of pure organic compounds and polymers. Measure melting point, glass transition, and enthalpy.

3. DTA of a multicomponent inorganic salt. Identify endothermic and exothermic transitions.
4. Interpretation of recorded TGA/DSC thermograms from literature or instruments.
5. SEM image analysis using provided micrographs. Measure particle size, surface texture, and morphology.
6. TEM micrograph interpretation. Determine lattice fringes, particle shape, and crystallite boundaries.
7. Visit/demo of SEM/TEM facility (if available). Instrument components, vacuum system, sample mounting.
8. Software simulation of electron beam interactions. Use open-source or institutional software for understanding signal generation.

ESSENTIAL/RECOMMENDED TEXTBOOKS

Theory:

1. **Skoog, Holler, and Crouch,** *Principles of Instrumental Analysis* (7th Ed.) – Cengage
2. **Willard, Merritt, Dean, and Settle,** *Instrumental Methods of Analysis* – CBS Publishers
3. **Tiwari, Ashutosh,** *Nanomaterials: A Guide to Fabrication and Applications* – Wiley
4. **Ertl, G., Knözinger, H., & Weitkamp, J.,** *Handbook of Heterogeneous Catalysis (vol. 1: Characterization Techniques)* – Wiley-VCH
5. **Brown, M.E.,** *Introduction to Thermal Analysis: Techniques and Applications* – Springer
6. **N.K. Kaushik and Shulka**, *Thermal Analysis Techniques and Applications*, IK International.

Practicals and Data Interpretation:

1. Practical Manual of Instrumental Techniques for Chemistry Students – University-level lab manuals
2. Lab Guide for Materials Characterization – Any departmental handout or material characterization facility guide
3. SEM/TEM Micrograph Interpretation Manual – Available from JEOL/FEI training resources
4. Online Spectral/Imaging Databases – NIMS, SpringerMaterials, NIST, etc.

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DISCIPLINE SPECIFIC ELECTIVE 9

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		

CHEMINFORMATICS	**4**	**2**	**0**	**2**	**12th Class: Physics, Chemistry, Mathematics**	**-**

Course Objectives:

- The aim of the course is to introduce the students to computational drug design through structure-activity relationship, QSAR and combinatorial chemistry. The students will learn about the target analysis, virtual screening for lead discovery, structure based and ligand-based design method and the use of computational techniques, library preparation and data handling.

Learning Outcomes:

By the end of the course, the students will be able to:

- Have a comprehensive understanding of drug discovery process and techniques including structure-activity relationship, quantitative structure activity relationship and the use of cheminformatics in this, including molecular modelling and docking studies.
- Appreciate role of modern computation techniques in the drug discovery process and perform their own modelling studies.

THEORY:

UNIT 1: **(4 hours)**

Introduction to Cheminformatics: History and evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular modelling and structure elucidation.

Representation of molecules and chemical reactions: Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

UNIT 2: **(12 hours)**

Searching chemical structures: Full structure search, sub-structure search, basic ideas, similarity search, three-dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

Applications: Prediction of Properties of Compounds; Linear Free Energy Relations; Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; Modeling Toxicity.

UNIT 3: **(6 hours)**

Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; Computer Assisted Structure elucidations; Computer Assisted Synthesis Design

UNIT 4: **(8 hours)**

Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand-Based and Structure Based Drug design; Application of Cheminformatics in Drug Design.

Practical: **(60 hours)**

1.Overview of Rational Drug Design, Ligands and Targets

2. In silico representation of chemical information

i. CIF IUCr Crystallographic Information Framework
ii. CML Chemical Markup Language
iii. SMILES -- Simplified Molecular Input Line Entry Specification
iv. InChi -- IUPAC International Chemical Identifier

3. Chemical Databases and Data Mining
   i. Cambridge Structural Database CCDC CSD
   ii. Crystallographic Open Database COD
   iii. Protein Data Bank PDB Ligand Explorer
   iv. Chemspider
4. Molecular Drawing and Interactive Visualization
   i. ChemDraw
   ii. MarvinSketch
   iii. ORTEP
   iv. Chimera, RasMol, PyMol
5. Computer-Aided Drug Design Tools
   i. Molecular Modeling Tools
   ii. Structural Homology Modeling Tools
   iii. Docking Tools and Screening Tools
6. Building a Ligand
   i. Building ab initio
   ii. Building from similar ligands
   iii. Building with a known macromolecular target
   iv. Building without a known macromolecular target
   v. Computational assessment of activity and toxicity and drugability.

References:

1. **Leach, A. R.; Gillet, V. J. (2007),** An introduction to Chemoinformatics**, Springer.**
2. **Gasteiger, J.; Engel, T. (2003),** Chemoinformatics: A text-book**. Wiley-VCH.**
3. **Gupta, S. P. (2011),**QSAR & Molecular Modeling**. Anamaya Pub.**
4. **Gasteiger, J.** Handbook of cheminformatics: from data to knowledge in 4 volumes, **Wiley.**

Note: **Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

DISCIPLINE SPECIFIC ELECTIVE 10

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		

CHEMICAL PATENT ANALYTICS & IP STRATEGY	**4**	**2**	**0**	**2**	**12th Class: Physics, Chemistry, Mathematics**	**-**

Course Objectives:

- Develop expertise in chemical patent analysis, drafting, and intellectual property (IP) strategy.
- Provide hands-on training in patent search methodologies, analytics, and database navigation.
- Foster understanding of IP commercialization, technology transfer, and portfolio management in the chemical industry.

Learning Outcomes:

By the end of this course, students will be able to learn:

- Analyze chemical patent systems, including Indian and global frameworks (USPTO, EPO, PCT).
- Conduct patent searches, patentability, freedom-to-operate (FTO) analyses, and landscape studies using AI and databases.
- Draft patent claims, specifications, and drawings for chemical inventions.
- Apply IP strategies for commercialization, licensing, and competitive intelligence.

THEORY COMPONENT-

UNIT 1: Chemical Patent Fundamentals (8 Hours)

Introduction to Chemical Patents**:** Anatomy of patent: Patent number, inventors, assignee, dates, title, abstract, background, summary, claims, description, drawing, embodiment, etc. Types of chemical patents: Composition, process, formulation, use patents, special considerations for biotechnology patents, differences between product and process patents in chemistry

Indian Patent System for Chemicals**:** Section 3(d) and its implications for pharma patents, compulsory licensing case studies (Bayer vs Natco), traditional knowledge protection (Turmeric, Neem cases)

Global Patent Systems**:** PCT filing for chemical inventions, USPTO and EPO requirements for chemical patents, Patent term extensions for agrochemicals

Patentability Criteria**:** Novelty assessment for chemical compounds, inventive step in process chemistry, industrial applicability requirements

UNIT 2: Patent Search & Analysis (8 Hours)

Search Methodologies: Keyword strategies for chemical searches, classification systems (IPC, CPC for chemistry), structure-based searching (Markush, SMILES, InChI)

Database Navigation**:** WIPO Patentscope deep dive, USPTO chemical patent search techniques, specialized chemistry databases (SciFinder, Reaxys), Google patent, Lens.org, FreePatentOnline, Derwent Innovation, PatSnap, Orbit Intelligence (Questel), PatBase, Reaxys, and SciFinder

Analytical Techniques**:** Citation analysis for identifying key patents, patent family mapping, competitive intelligence through assignee analysis

Freedom-to-Operate Analysis**:** Risk assessment methodology, case study: generic drug entry strategies

UNIT 3: Patent Drafting for Chemists (8 Hours)

Claim Drafting Strategies**:** Composition claims vs process claims, Markush language for chemical structures, dependent claim strategies

Specification Writing: Detailed description requirements, examples and embodiments, data presentation best practices

Special Cases: Polymorph patents, formulation patents, biotech sequence listings

Drawings and Diagrams: Chemical structure drawings, Process flow diagrams, spectra presentation

UNIT 4: IP Commercialization (6 Hours)

Technology Transfer: University-industry collaborations, licensing strategies, startup formation

Portfolio Management**:** Patent valuation methods, maintenance decision making, defensive publishing, **case Studies:** Novartis Glivec case, agrochemical patent strategies. green chemistry patents,

PRACTICAL COMPONENT (60 Hours)

1. Basic Excel Training (May use AI tools as well)
Essential formulas:
VLOOKUP (for patent family matching)
COUNTIF (for assignee analysis)
Pivot Tables (for technology trend analysis)
Conditional Formatting (highlighting key patents)
Data cleaning techniques for patent exports
2. Database Navigation and Export
WIPO Patentscope, USPTO, Espacenet, Google Patent, Lens.org, FreePatentsOnline
Non-Patent Literature data bases (Google Scholar, Science direct, Scopus, Scopus AI)
3. Novelty Search (Invention from any recent patent application)
Task: Identify prior art for a given invention
Tools**:** Any freely available data base including AI tools
Deliverable: Excel report with key patents ranked by relevance and novelty assessment summary
5. FTO Search (Provide an invention from any recent granted patent)
Task: Analyze freedom-to-operate for a provided invention
Tools: Any freely available data base including AI tools

Deliverable: Risk assessment matrix in Excel

6. Invalidity Search (Provide a recent granted patent)

Task: Find invalidating prior art for a granted patent

Tools: Any freely available data base including AI tools

Deliverable: Evidence chart in Excel

7. Claim Drafting (Provide an Invention disclosure from a patent)

8. Group project + viva presentation on landscape study

Task: Any topic in a particular interval (2020 to 2025) and convert landscape study into PowerPoint

Tools: Any freely available data base including AI tools, excel, and PPT

Deliverable: Pivot table showing: Top assignees and Technology evolution

Requirements: Technology trends slides, competitor analysis.

RECOMMENDED/ESSENTIAL TEXTBOOKS AND REFERENCES

1. WIPO, WIPO Patent Drafting Manual (2023) – World Intellectual Property Organization (https://www.wipo.int/edocs/pubdocs/en/wipo-pub-867-23-en-wipo-patent-drafting-manual.pdf)
2. Sampat BN, Shadlen KC. Indian pharmaceutical patent prosecution: The changing role of Section 3(d). PLoS One. 2018 Apr 2;13(4):e0194714. doi: 10.1371/journal.pone.0194714. PMID: 29608604; PMCID: PMC5880378.
3. WIPO, Guidelines for Preparing Patent Landscape Reports(2015)-World Intellectual Property Organization (https://www.wipo.int/edocs/pubdocs/en/wipo_pub_946.pdf)
4. WIPO, Patent Coorperation Treaty(PCT)- Regulations under the PCT (as in force from July 1, 2024) (https://www.wipo.int/edocs/pubdocs/en/wipo-pub-274-2024-en-patent-cooperation-treaty-pct.pdf)
5. WIPO, Guide to the International Patent Classification (2025)-World Intellectual Property Organization (https://www.wipo.int/edocs/pubdocs/en/wipo-guide-ipc-2025-en-guide-to-the-international-patent-classification-2025.pdf)
6. WIPO, Inventing the Future-An Introduction to Patents for Small and Medium-sized Enterprises (2018)- World Intellectual Property Organization (https://www.wipo.int/edocs/pubdocs/en/wipo-pub-917-1-en-inventing-the-future.pdf)
7. WIPO, Identifying Inventions in the Public Domain-A Guide for Inventors and Entrepreneurs (2020)- World Intellectual Property Organization (https://www.wipo.int/edocs/pubdocs/en/wipo_pub_1062.pdf)
8. https://www.uspto.gov/patents/basics

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE 11

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
FUNDAMENTALS OF MEDICINAL CHEMISTRY	4	2	0	2	12th Class: Physics, Chemistry, Mathematics	-

****For syllabus content of Discipline Specific Elective-11: (DSE-11) "Fundamentals of Medicinal Chemistry" refer to the syllabus content of DSE-20 of B Sc. Physical Sciences Programme.**

GENERIC ELECTIVE

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
INDUSTRIAL POLLUTION-IMPACTS& REMIDIES	**4**	**2**	**0**	**2**	**12th Class: Physics, Chemistry, Mathematics**	**-**

Course Objectives

- To understand the sources, types, and impacts of industrial and environmental pollutants.
- Study remediation techniques and sustainable practices for pollution control.
- Develop hands-on skills for pollutant analysis using non-sophisticated methods.
- Analyze case studies of environmental disasters and policy responses.

Learning Outcomes

By the end of the course, students will be able to:

- Classify major pollutants (air, water, soil) and describe their environmental pathways.
- Explain the chemistry behind pollution effects (e.g., acid rain, bio-magnification).
- Perform basic pollutant detection and remediation experiments.
- Evaluate Indian and global environmental regulations (CPCB, NGT, Paris Agreement).
- Propose sustainable solutions using green chemistry principles.

THEORY COMPONENT

Unit 1: Fundamentals of Pollution Types (8 Hours)

- **Types of Pollution**: Air, water, soil, noise, thermal - definitions, key features, and examples from urban and industrial settings.
- **Pollutant Classification**: Organic pollutants (e.g., volatile organic compounds, pesticides, PAHs), inorganic pollutants (e.g., heavy metals, acids, ammonia), and particulate matter (PM2.5, PM10).
- **Sources of Pollution**: Natural vs. anthropogenic; emissions from chemical industries, fossil fuel combustion, mining operations, fertilizer and pesticide use, and urban waste.
- **Environmental Pathways**: Introduction to pollutant transport and fate — atmospheric deposition, leaching into groundwater, surface runoff, bioaccumulation, and biomagnification in food chains.

Unit 2: Impacts and Monitoring **(7 Hours)**

- **Health Effects of Pollutants**: Acute and chronic impacts — respiratory diseases, carcinogenicity (benzene, dioxins), neurotoxicity (lead, mercury), endocrine disruption.
- **Ecosystem Damage**: Eutrophication of water bodies, degradation of soil fertility, deforestation, and loss of biodiversity.
- **Climate Linkages**: Role of CO_2, CH_4, and N_2O in global warming; CFCs and ozone layer depletion; interconnections between local pollution and global environmental change.
- **Case Studies**:
  Bhopal Gas Tragedy (1984): Methyl isocyanate release and its aftermath
  Minamata Disease (Japan): Industrial mercury poisoning

Unit 3: Environmental Laws & Policies **(7 Hours)**

- **Indian Regulations**:
  Water (Prevention and Control of Pollution) Act, 1974
  Air (Prevention and Control of Pollution) Act, 1981
  Environment Protection Act (EPA), 1986
  Role of the National Green Tribunal (NGT) in enforcement
- **Global Frameworks**:
  Kyoto Protocol: Binding targets for developed nations
  Paris Agreement: Global commitment to climate mitigation
- **Monitoring Techniques**:
  Air: *AQI metrics, stack emission sampling, ambient air samplers*
  Water: *Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), heavy metal testing, TDS*
  Soil: *pH, electrical conductivity, nutrient levels, contaminant profiling (e.g., lead, arsenic)*

Unit 4: Remediation & Sustainability **(8 Hours)**

- **Remediation Techniques**:
  Physical Methods: Filtration, adsorption using activated charcoal, sedimentation
  Chemical Methods: Precipitation of heavy metals, neutralization of acid/alkali wastes, oxidation-reduction methods
  Biological Methods: Bioremediation (microbial degradation), phytoremediation (use of plants like *Brassica*, *Eichhornia*)
- **Green Chemistry Approaches**: 12 principles of green chemistry, pollution prevention at the source, eco-friendly solvents, catalysis, energy-efficient synthesis
- **Circular Economy Concepts**: Resource reuse, closed-loop systems, industrial symbiosis, cradle-to-cradle design
- **Corporate Environmental Responsibility**:
  CSR initiatives in environmental conservation
  Zero-liquid discharge (ZLD) in process industries
  Extended Producer Responsibility (EPR) in plastic and electronics sectors

PRACTICAL COMPONENT **(60 hours)**

1. pH and acidity testing of effluents (comparison of household and industrial acids)
2. Test for coagulation-flocculation (alum treatment of turbid water)
3. Qualitative detection of heavy metals (lead/iron) using sodium sulfide

4. Dissolved oxygen estimation using Winkler's method
5. Soil salinity test using conductivity meter
6. Colorimetric adsorption study (methylene blue on charcoal or silica)
7. Noise pollution mapping using smartphone dB meters in campus zones
8. Airborne particulate capture using sticky tapes and microscopic analysis
9. Neutralization experiments with acidic waste (lime, baking soda titration)
10. Oil–water separation using charcoal/cotton filters.

RECOMMENDED/ESSENTIAL TEXTBOOKS AND REFERENCES

Textbooks:

De, A. K., *Environmental Chemistry* – New Age International.

Manivasakam, N., *Industrial Pollution Control* – SS Publishers.

Anastas, P. T., & Warner, J. C., *Green Chemistry: Theory and Practice* – Oxford University Press.

Pepper, I. L., Gerba, C. P., & Brusseau, M. L., *Pollution Science* – Academic Press.

Walker, P., & Wood, E., *Environmental Science Experiments* – Facts on File.

Thomas, W. J., *Adsorption Technology & Design* – Butterworth-Heinemann.

Smith, K. A., & Mullins, C. E., *Soil and Environmental Analysis* – CRC Press.

Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R., *Fundamentals of Analytical Chemistry* (9th Edition) – Cengage Learning.

Vogel, A. I., Svehla, G., Jeffery, G. H., & Mendham, J., *Vogel's Qualitative Inorganic Analysis* (7th Edition) – Pearson.

Vowles, P. D., & Connell, D. W., *Experiments in Environmental Chemistry* – Elsevier.

Boyd, C. E., *Water Quality: An Introduction* – Springer.

Reports & Guidelines:

- CPCB (Central Pollution Control Board) publications.
- UNEP (United Nations Environment Programme) reports.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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COURSES OFFERED BY DEPARTMENT OF CHEMISTRY

B Sc. Physical Sciences

Undergraduate Programme of study

(with Chemistry as the Major Disciplines)

Semester-wise Distribution of Discipline Specific Core (DSC) Courses

DISCIPLINE CORE COURSES –02 (4 Credits each)			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
VII	**DSC-19**	Chemistry of d- and f- block elements, Advanced Organic Spectroscopy and Quantum Chemistry	T=3 P=1
VIII	**DSC-20**	Catalysis, Photocatalysis, Application of Reagents in Organic Synthesis and Statistical Thermodynamics	T=3 P=1

DISCIPLINE SPECIFIC ELECTIVE COURSES – (4 Credits each)			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
VII	**Common Pool of DSE Courses applicable for both B.Sc. Physical Sciences and B.Sc. Life Sciences**		
	DSE-14	Industrial Chemicals and Environment	T=2 P=2
	DSE-15	Advanced Stereochemistry	T=2 P=2
	DSE-16	Reactive Intermediates of Organic Chemistry	T=2 P=2
	DSE-17	Molecular Spectroscopy and Structural Analysis	T=2 P=2
	DSE Course applicable specifically for B.Sc. Physical Sciences		
	DSE-18 PS	Introductory Interfacial Electrochemistry	T=2 P=2
VIII	**Common Pool of DSE Courses applicable for both B.Sc. Physical Sciences and B.Sc. Life Sciences**		
	DSE-19	Fundamentals of Natural Products	T=2 P=2
	DSE-20	Fundamentals of Medicinal Chemistry	T=2 P=2
	DSE-21	Computational Chemistry	T=2 P=2
	DSE-22	Machine Learning and Artificial Intelligence in Chemistry*	T=2 P=2
	DSE Course applicable specifically for B.Sc. Physical Sciences		
	DSE-23 PS	Crystalline Solids: Properties and Methods of Analysis	T=2 P=2
	DSE-24 PS	Coordination Chemistry, Reaction Mechanism and Spectral properties	T=2 P=2

*** For syllabus content of Discipline Specific Elective-22 (DSE-22) "**Machine Learning and Artificial Intelligence in Chemistry" **refer to DSE syllabus of B.Sc. (H) Chemistry**.

Note: A student, studying in 4^{th} year of B.Sc. Physical Science/Life Science Programme, desirous of opting any *Discipline Specific Elective* (DSE) Course from progression of DSE courses available in Semester III-VI of the programme, may be allowed to opt the same in the VII^{th} or $VIII^{th}$ semester.

DISCIPLINE SPECIFIC CORE COURSE - 19 (DSC-19): Chemistry of d- and f-Block Elements, Advanced Organic Spectroscopy and Quantum Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemistry of d- and f-block elements, Advanced Organic Spectroscopy and Quantum Chemistry **(DSC-19)**	**04**	**03**	**-**	**01**	**Class 12^{th} with Physics, Chemistry and Maths**	**--**

Course Objectives

The objectives of this course are as follows:

- To provide thorough knowledge about the d- and f- block elements with respect to the general group trends, physical and chemical properties of these elements.
- To impart the knowledge about synthetic methods and principles of chromatography.
- Understanding spectroscopic techniques and their application in the structural elucidation of organic molecules.
- To explain the concept of linear Hermitian operators and commutation of operators and applications.
- To apply the postulates for deriving equations of various models and extend it to hydrogen atom and hydrogen like atoms.
- To explain the valence bond and molecular orbital theories and their applications to simple molecules

Learning outcomes

By studying this course, students will be able to:

- Analyse the important properties of transition metals, lanthanoids, and actinoids
- Understand Latimer diagrams to predict and identify species which are reducing, oxidizing and tend to disproportionate and calculate skip step potentials.

- Apply the principles of synthesis of Inorganic compounds and chromatographic separation of metal ions.
- Develop an understanding of the basic principles of NMR spectroscopy, such as chemical shift, coupling constant, and anisotropy, and describe how they are affected by molecular structure, and identify organic compounds by analysis and interpretation of spectral data.
- Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle
- Understand Schrodinger equations for different types of systems
- Analyse different wavefunctions and probability distribution curves.

UNIT- 1: Chemistry of Transition Elements (15 Hours)

General group trends with special reference to electronic configuration, colour, variable valency, magnetic properties, catalytic properties, and ability to form complexes. Stability of various oxidation states and EMF (Latimer diagrams), Frost diagrams of Mn and Cr. A brief discussion of differences between the first, second and third transition series

A brief discussion of electronic configuration, oxidation states, colour, spectral and magnetic properties. Lanthanoid contraction (causes and effects), separation of lanthanoids by ion exchange method.

UNIT-2: Spectroscopic Techniques in Organic Chemistry (15 Hours)

Recapitulation of the Spectroscopic Techniques (UV- VIS, IR, and ^{1}H NMR)

Carbon-NMR Spectroscopy

Resolution and multiplicity of ^{13}C NMR, ^{1}H-decoupling, noise decoupling, broadband decoupling; Deuterium, fluorine, and phosphorus coupling; NOE signal enhancement, Off resonance, proton decoupling, Structural applications of CMR. DEPT and general introduction about 2D NMR.

Mass Spectrometry

Theory, Fourier transform mass spectrometry instrumentation (FTMS); Unit mass and molecular ions; Important terms singly, doubly/multiple charged ions, metastable peak, base peak, isotopic mass peaks, relative intensity; Recognition of M^{+} ion peak; Nitrogen rule; Rule of 13; Ionization methods (EI and ESI). General fragmentation rules: McLafferty rearrangement, ortho effect.

ESR Spectroscopy

Basic Principles and applications for organic Compounds.

Structure Elucidation

Structure elucidation of Organic Compounds Using UV, IR, NMR, and Mass Spectra.

Unit-3: Properties of operators, Particle in a Box, Harmonic Oscillator and Hydrogen Atom (6 Hours)

Linear and Hermitian operators, Turn-over rule, Commutation of operators, and Uncertainty principle. Angular momentum operators, Eigenvalues and eigenfunctions, Particle in a box (3-D) and ring, and the concept of degeneracy.

Calculation of various average values ($\langle x \rangle$, $\langle p \rangle$, $\langle x^2 \rangle$ and $\langle p^2 \rangle$) for simple harmonic oscillator. Calculation of the probabilities and most probable values of hydrogen 1*s* wavefunction.

Unit-4: Approximation Methods, Many Electrons Atom and Chemical Bonding (9 Hours)

First order time-independent perturbation theory for non-degenerate states, Variation theorem and variational methods. Use of these methods illustrated with some examples (particle in a box with a finite barrier, He atom).

Indistinguishability of the electrons and their intrinsic spin, spatial and spin wavefunctions, Pauli's Exclusion principle. Many-electron atom (Qualitative discussion).

Chemical bonding: Born-Oppenheimer approximation. Setting up of wavefunction of $\boldsymbol{H_2^+}$ using Valence bond theory approach and qualitative discussion of solutions. Linear Combination of Atomic Orbitals (LCAO), salient features of MO theory and setting up of wavefunction of $\boldsymbol{H_2}$,

Practical: Credits: 01
(Laboratory periods: 15 classes of 2 hours each)

PART A : INORGANIC CHEMISTRY

Inorganic Preparations

1. Potassium aluminium sulphate $KAl(SO_4)_2.12H_2O$ (potash alum} or Potassium chromium sulphate $KCr(SO_4)_2.12H_2O$ (chrome alum}.
2. Manganese phosphate and
3. Sodium peroxoborate

Paper chromatographic separation of following metal ions (minimum two should be done):

4. Ni(II) and Co(II)
5. Cu(II) and Cd(II)
6. Fe(III) and Al(III)

PART B: ORGANIC CHEMISTRY
(Note: Spectra to be provided wherever required)

7. Diels-Alder reaction between maleic anhydride and anthracene and identification of the product using IR and NMR Spectroscopy.
8. Knoevenagel condensation between aromatic aldehydes (benzaldehyde/*p*-nitro benzaldehyde) and active methylene compounds (malononitrile/ethyl cyanoacetate/ diethylmalonate) and identification of the product using IR and NMR Spectroscopy.
9. Differentiate between maleic and fumaric acid solutions by UV spectroscopy.

10. Demonstration of the separation of the mixture of *p*-nitrophenol and *o*-nitrophenol by column chromatography and their characterization by melting point and spectroscopic techniques.

PART C: PHYSICAL CHEMISTRY

11. Plot the radial wavefunctions and probability distribution for H atom's 1s, 2s, 2p orbital using software i.e. MS-EXCEL.

12. (i) Draw probability plots for a particle in a 1-dimensional box for different values of quantum number n - commenting on the number of points of zero probability and then correlate them with the correspondence principle.

    (ii) Calculate the bond length of conjugated dye molecules (i.e., cyanine/β-carotene) using particle in 1D box model.

13. (i) Setting up of Schrödinger equation of Many-electron atoms and cite limitations to carry out exact solution of the problem.

(ii) Carry out calculation of various average values ($\langle x \rangle$, $\langle p \rangle$, $\langle x^2 \rangle$ and $\langle p^2 \rangle$) for simple harmonic oscillator using MS-EXCEL.

14. Demonstrate the variational treatment of hydrogen molecule ion and also exhibit Valence bond and Molecular orbital (LCAO) treatment of hydrogen molecule. Calculation of HOMO and LUMO energies using computational software; Comparison of HOMO and LUMO energies relative to H-atom.

15. Demonstration of shapes and electronic features of bonding and antibonding $\boldsymbol{\sigma}$ and $\boldsymbol{\pi}$ orbitals on a visualization software.

Essential/recommended readings

Theory

1. Lee, J. D. (2010), Concise lnorganic Chemistry, Wiley lndia.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O. K.(2009), lnorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
4. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.
5. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons.
6. Cotton, F.A.; Wilkinson, G. (1999), Advanced Inorganic Chemistry, Wiley-VCH.
7. Das, A. K.; Das, M. (2014), Fundamental Concepts of Inorganic Chemistry, 1st Edition, Volume 1-3, CBS Publishers & Distributors Pvt. Ltd.
8. S. K. Ghuman, A.Sakthivel, D. T. Masram, M.Sathiyendiran, (2017) Electronic and Magnetic properties of transition and inner transition elements and their complexes,

Nova Science Publishers, New York.

9. Chandrashekhar,V. (2005}, Inorganic and Organometallic Polymers, 5th Edition, Springer Publications.
10. Kemp, W. Organic Spectroscopy 3rd Ed., W. H. Freeman & Co. (1991).
11. Silverstein, R. M., Bassler, G. C. & Morrill, T. C. Spectroscopic Identification of Organic Compounds. John Wiley & Sons (1981).
12. Pavia, D. L.; Lampmann, G. M.; Kriz, G. S.; Vyvyan, J. R. Introduction to Spectroscopy. Cengage Learning (2014).
13. Organic Structures from spectra; L. D. Field, S. Sternhell and J R Kalman, John Wiley & Sons Ltd., 2007
14. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.
15. Bakhshi, A. K. & Thakral P., Quantum Chemistry Simplified Vidyavani Foundation: New Delhi (2025) (ISBN: 9788196225107).
16. House, J.E. (2004), Fundamentals of Quantum Chemistry, 2nd Edition, Elsevier.
17. McQuarrie, D.A. (2016), Quantum Chemistry, Viva Books.
18. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
19. Atkins, P.W.; Friedman, R. (2010), Molecular Quantum Mechanics, 5th Edition, Oxford University Press.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons,
2. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company.
3. Day, R. A.; Underwood, A. L. (2012), Quantitative Analysis, Sixth Edition, PHI Learning Private Limited.
4. Marr, G.; Rockett, B.W. (1972), Practical Inorganic Chemistry, Van Nostrand Reinhold.
5. Vogel, A. I. (2012). Quantitative Organic Analysis, Part 3, Pearson Education.
6. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
7. Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A. R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
8. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
9. Morrill, L. A., Kammeyer, J. K., & Garg, N. K. (2017). Spectroscopy 101: A practical introduction to spectroscopy and analysis for undergraduate organic chemistry laboratories. *J. Chem. Educ.* 94 (10), 1584-1586.
10. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.
11. McQuarrie, D. A. (2008) Mathematics for Physical Chemistry University Science Books.
12. Mortimer, R. (2005) Mathematics for Physical Chemistry. 3rd Ed. Elsevier.
13. Steiner, E. (1996) The Chemical Maths Book Oxford University Press.

14. Yates, P. (2007) Chemical Calculations. 2nd Ed. CRC Press.
15. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages.
16. Noggle, J. H. Physical Chemistry on a Microcomputer. Little Brown & Co. (1985).

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC CORE COURSE - 20 (DSC-20): Catalysis, Photocatalysis, Application of Reagents in Organic Synthesis and Statistical Thermodynamics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Catalysis, Photocatalysis, Application of Reagents in Organic Synthesis and Statistical Thermodynamics **(DSC-20)**	**04**	**03**	**--**	**01**	**Class 12th with Physics, Chemistry, Maths**	**--**

Course Objectives

The objectives of this course are as follows:

- To imparts basic knowledge of Organometallic compounds and catalysis,
- To enrich students with the knowledge of various types of bonding and structure of organometallic compounds and biocatalysts.
- To impart the theoretical and practical knowledge of catalysts with the view of their industrial applications.
- To facilitate chemical transformations by providing the necessary conditions and catalysis.
- To provide a brief foundational understanding of the core principles of statistical thermodynamics.
- To study the connection between macroscopic thermodynamics and microscopic quantum mechanics utilizing various statistical ensembles.
- To study Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics with a brief, qualitative understanding and focus on their applications.
- To enable students to apply statistical concepts in key areas such as the standard model, chemical kinetics, and chemical equilibrium.

Learning outcomes

By studying this course, the students will be able to:

- Develop understanding on of the role of catalyst in industrial applications.

- Gain sound knowledge of various types of catalyst.
- Develop skilled in the scientific method of planning, developing, conducting, reviewing and reporting experiments.
- Develop skilled concepts of industrial catalysis which will help them to explore new innovative areas of research
- Understand various reducing agents, oxidizing agents, and their applications in organic synthesis.
- Understand the conversion of specific functional groups without affecting others and maximize yields and selectivity for the desired products
- Understand the fundamental principles of statistical mechanics, including how they link microscopic behaviour to macroscopic properties of systems.
- Apply the Boltzmann distribution, Bose-Einstein statistics, and Fermi-Dirac statistics in various physical and chemical systems.
- Analyse and solve problems related to the thermodynamic properties of systems using partition functions.
- Explore the application of statistical mechanics to key areas such as chemical kinetics, chemical equilibrium, and random walk models in macromolecular systems.

UNIT- 1: Catalysis and Photocatalysis (15 Hours)

General principles of catalysis, properties of catalysts, Mode of action of catalyst, Types of catalyst (homogeneous and heterogeneous catalysis), Deactivation and regeneration of catalysts, catalytic poison, Promoter, Turnover frequency, Turnover number, Specificity and selectivity.

Catalysis in environmental remediation, eco-friendly energy solutions and production of valuable chemicals.
Study of the following industrial processes, catalytic cycle and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst).
2. Synthetic gasoline (Fischer Tropsch reaction).
3. Polymerisation of ethene using Ziegler-Natta catalyst.
4. Wacker-Smith synthesis of aldehyde.

Photocatalysis: Basic principle, Mechanism, Types of Photocatalysts, band gap, tuning of band gap, doping, UV- visible light lamp source, UV-visible light filters, Water Splitting, Photoreduction and oxidation of water, Brief discussion of example of Photocatalysis: Photosynthesis, Pollutant degradation, Hydrogen production, CO_2 conversion.

UNIT- 2: Synthesis and applications of Reagents in Organic Synthesis (15 Hours)

Synthesis and applications of BuLi, Grignard, organoaluminium, and organozinc reagents**.**

Triacetoxyborohydride, Lead Acetate, Phenyliodine (III) diacetate (PIDA), DCC, Tamao-Fleming Oxidation; Dimethyldioxirane (DMDO) Oxidation; DMSO (Barton modification & Swern Oxidation); Oxidation of organic compounds using thallium nitrate, selenium dioxide, phase transfer catalyst, crown ethers, $KMnO_4$, PCC, OsO_4, CrO_3, $K_2Cr_2O_7$**.**
Applications of hydroboration (reductions, oxidations, and carbonylation): Diborane, 9-BBN.

UNIT- 3: Elements of Statistical Mechanics (10 Hours)
Microstates, Configurations, tossing of coins, rolling of dices and spin of electrons in absence of magnetic field, most probable thermodynamic probability, Stirling's Approximation, Concepts of ensembles, Microcanonical, Canonical ensembles, Qualitative Discussion of translational, vibrational, and rotational Partition functions, Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac Statistics (Qualitative discussions)

UNIT- 4: Conventional Transition State Theory and Brownian Motion (5 Hours)
Conventional transition state theory in terms of molecular partition functions, gas phase equilibrium constant in terms of partition function, 1-D random walk model, Brownian Dynamics (Qualitative discussion only).

Practicals: Credits: 01

(Laboratory periods:15 classes of 2 hours each)

PART A : INORGANIC CHEMISTRY

1. Synthesis of "Zeolite A" catalyst.
2. Zeolite Hydrogen-Y or dil.HC1/dil.H_2SO_4 as a Catalyst for the Preparation of an Ester.
3. Catalytic Synthesis of biaryl.
4. Catalytic Transfer Hydrogenation of Castor Oil
5. Reduction of Nitrobenzene
6. Synthesis of Cu_2O, TiO_2, Fe_3O_4, ZnO, and NiO Nanoparticles and characterization by UV/Vis spectroscopy.
7. Photocatalytic degradation of Methylene Blue dye using Cu_2O, TiO_2, Fe_3O_4, ZnO, and NiO Nanoparticles and UV/Vis studies.

PART B : ORGANIC CHEMISTRY

8. Identification of the product based on Melting point and spectroscopic techniques (IR, ^{1}HNMR, and ^{13}C NMR spectroscopy, data to be provided).
9. Synthesis of 1,2,3,4-tetrahydrocarbazole from cyclohexanone.
10. Reduction of *p*-nitrobenzaldehyde using $NaBH_4$
11. Synthesis of 2,3-diphenylquinoxaline from benzil and *ortho*-phenylenediamine.
12. Oxidation of benzyl alcohol by $KMnO_4$.

PART C: PHYSICAL CHEMISTRY

13. Study of kinetics of the iodination of acetone in the presence of acid by the *Initial Rate Method*.
14. Statistical Treatment of Error Analysis (Null Hypothesis, T-test, F-test, Q-test (criteria for rejection of hypothesis) Statistical analysis of laboratory data.

15. Determination of standard deviation, mean, and maximum absolute errors, root-mean-square deviation (error), and Correlation coefficient of linear straight-line plot.

Essential/recommended readings

Theory:

1. Huheey, J. E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education.
2. Cotton, F.A.; Wilkinson, G. (1999), Advanced Inorganic Chemistry, Wiley-VCR.
3. Jens Hagen (2015) Industrial Catalysis: A Practical Approach Wiley-VCR Verlag GmbH&Co
4. Carruthers, W. Modern Methods of Organic Synthesis. Cambridge University Press (1996).
5. Carey, F.A. & Sundberg, R. J. Advanced Organic Chemistry, Parts A & B, Plenum: U.S. (2004).
6. Jonathan Clayden, Nick Greeves, Stuart Warren. Organic Chemistry. Oxford. (2000)
7. McQuarrie, D. A. *Statistical Mechanics,* Viva Books Pvt. Ltd.: New Delhi (2003).
8. Reif, Frederick., Fundamentals of Statistical and Thermal Physics, McGraw-Hill, (1965).
9. Huang, Kerson, Statistical Mechanics, 2nd ed., Wiley (1987).
10. Pathria, R. K., and Paul D. Beale, Statistical Mechanics, 3rd ed., Elsevier (2011).
11. Pal, Palash B., (2008) Statistical Mechanics: Principles and Applications, Narosa Publishing House.
12. Bagchi B., (2018) Statistical Mechanics for Chemistry and Material Science, CRC Press.
13. L. D. Landau and E. M. Lifshitz, (2005) Statistical Mechanics, Part I, Butterworth-Heinemann, 3rd ed.
14. Laidler, K. J. (1997) *Chemical Kinetics* 3rd Ed., Benjamin Cummings.
15. Atkins, P. W. & Paula, J. de (2006) *Atkin's Physical Chemistry* 8th Ed., Oxford University Press.
16. McQuarrie, D. A. & Simon, J. D. (2001) *Physical Chemistry: A Molecular Approach* 3rd Ed., Univ. Science Books.

Practical:

1. Williams, D. J.; Huck, B. E.; Wilkinson, A. P. First-Year Undergraduate Laboratory Experiments with Zeolites Chem. Educator 2002, 7, 33-36.
2. Coker, E. N.; Davis, P. J.; Experiments with Zeolites at the Secondary-School Level: Experience from The Netherlands Journal of Chemical Education 1999, 76, 10, 1417.
3. Hanson RW. Catalytic transfer hydogenation reactions for undergraduate practical programs. J Chem Educ. 2009, 74, 430.
4. Alwaseem H, Donahue CJ, Marincean S. Catalytic transfer hydrogenation of castor oil. J Chem Educ. 2014; 91, 575-8.
5. Ramesh R; Rajendran A.; Photocatalytic dye degradation activities of green synthesis of cuprous oxide nanoparticles from Sargassum wightii extract, Chemical Physic Impact, 2023, 6, 100208.

6. Ahluwalia, V. K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
7. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
8. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
9. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi
10. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
11. McQuarrie, D. A. & Simon, J. D. (2001) *Physical Chemistry: A Molecular Approach* 3rd Ed., Univ. Science Books.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SEMESTER VII

Discipline Specific Elective Courses (Common Pool) applicable for both B.Sc. Life Sciences and B.Sc. Physical Sciences

Discipline Specific Elective Course – 14 (DSE-14): Industrial Chemicals and Environment**

****For syllabus content of Discipline Specific Elective-14: (DSE-14)** "Industrial Chemicals and Environment" refer to the syllabus content of **DSE-14** of **B Sc. Life Sciences Programme**.

Discipline Specific Elective Course – 15 (DSE-15): Advanced Stereochemistry**

****For syllabus content of Discipline Specific Elective-15: (DSE-15)** "Advanced Stereochemistry" refer to the syllabus content of **DSE-15** of **B Sc. Life Sciences Programme**.

Discipline Specific Elective Course – 16 (DSE-16): Reactive Intermediates of Organic Chemistry**

For syllabus content of Discipline Specific Elective-16: (DSE-16) "Reactive Intermediates of Organic Chemistry" refer to the syllabus content of **DSE-16** of **B Sc. Life Sciences Programme**.

Discipline Specific Elective Course – 17 (DSE-17): Molecular Spectroscopy and Structural Analysis**

For syllabus content of Discipline Specific Elective-17: (DSE-17) "Molecular Spectroscopy and Structural Analysis" refer to the syllabus content of **DSE-17** of **B Sc. Life Sciences Programme**.

Discipline Specific Elective Courses Applicable Specifically for B.Sc. Physical Sciences

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE

Discipline Specific Elective Courses –18 PS (DSE-18 PS): Introductory Interfacial Electrochemistry

COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introductory Interfacial Electrochemistry **(DSE-18 PS)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	**--**

Course Objectives

The objectives of this course are as follows:

- To discuss the electrochemical cells and Faradaic and Nonfaradaic Processes.
- To develop an understanding of electrical double layer and various equivalent circuit models of electrical double layer.
- To enable learners to have an insight into electrode kinetics and evaluation of kinetic parameters.
- To explain nature of electrode processes using cyclic voltammograms.
- To provide hands-on experience with setting up of electrochemical cells, quantitative estimation and evaluation of important physical quantities.

Learning outcomes

By studying this course, the students will be able to:

- Develop an understanding of working, counter electrode and differentiate between various reference electrodes along with the nature of electrode process.
- Understand the concept of electrical double layer and various equivalent models of the electrical double layer.

- Understand kinetics parameters from Tafel plot and thus demonstrate understanding of electrode kinetics, Butler-Volmer equation; its physical implications and cyclic voltammograms.
- Understand various applications of electrochemistry i.e. electrocatalysis, transport in electrolyte solution, conversion and storage of electrochemical energy.
- Perform hands-on laboratory exercise and interpret results of important electrochemical techniques i.e. cyclic voltammetry.

Theory:

Unit 1 Electrochemical Cells and Reaction - (6 Hours)

Working and Counter Electrodes, Reference Electrodes: standard hydrogen electrode (SHE), or normal hydrogen electrode (NHE), saturated calomel electrode (SCE), silver-silver chloride electrode, potential of zero charge, open-circuit potential of the cell, overpotentials. Faradaic and Nonfaradaic Processes: ideal polarized (or ideal polarizable) electrode, Capacitance and Charge of an Electrode, supporting electrolyte.

Unit 2: Electrical Double Layer (8 Hours)

Description of the Electrical Double Layer: inner and outer compact layer Helmholtz, or Stern layer, Diffuse Layer, specifically and non-specifically adsorbed ions, Potential profile across the double-layer region in the absence of specific adsorption of ions, Equivalent circuit models of EDL, Gouy-Chapman Model, qualitative Graham-Devanathan-Mottwatts, Tobin, Bockris, Devanathan model.

Unit 3: Electrode Kinetics (8 Hours)

Electrode Kinetics: Formal and Equilibrium Potentials, Overpotentials, Derivation of Butler-Volmer equation and its physical implications, Exchange current density and transfer coefficient, Evaluation of kinetics parameters from Tafel plot. Explain reversible, quasireversible, irreversible and capacitive response using cyclic voltammograms.

Unit 4: Applications of Electrochemistry (8 Hours)

Electrocatalysis: Influence of various parameters on water splitting, HER and OER.
Corrosion: Introduction to corrosion, forms of corrosion, General description of Corrosion monitoring and prevention.
Transport in Electrolyte Solution: Qualitative discussion of Fick laws and equations of Einstein on diffusion.
Conversion and Storage of Electrochemical Energy: Fuel cells, Supercapacitors and Li ion batteries, Redox flow batteries.

Practicals: Credits: 02

(Laboratory periods:15 classes of 4 hours each)

1. Conductometric Titration of a Charge Transfer System, the formation of charge transfer complex between an electron donor and acceptor is studied and the stoichiometry of the complex is determined by following the variation of conductance of the solution with concentration of the donor and acceptor.
2. Effect of ionic strength on reaction rate (persulfate-iodine reaction).

3. Potentiometric determination of solubility and solubility product of AgCl(s) in water.
4. Potentiometric determination of mean ionic activity coefficient of HCl at different concentrations.
5. Potentiometric titration of Phosphoric acid vs NaOH.
6. Determination of dissociation constant of acetic acid from its potentiometric titration curve.

Hands-on/Demonstration/ Instruction Mode*: Demonstration/ Discussion of working principle/ Hands-on with substantial literature analysis/ Laboratory exercise.

7. Record cyclic voltammogram for the electrochemical capacitors (electric double layer) response with varying scan rates,
   i) plot anodic and cathodic plateau currents vs scan rates.
   (Use aqueous solution of 1.5 M $NaNO_3$)
8. Record cyclic voltammogram for a reversible heterogeneous electron transfer system with varying scan rates,
   (i) Determine anodic and cathodic peak current ratio.
   (ii) Determine anodic and cathodic peak potential difference.
   (iii) Plot peak current vs square root of scan rates.
   (Use aqueous solution of 10 mM $K_4Fe(CN)_6$ + $K_3Fe(CN)_6$ + 1.5 M $NaNO_3$)
9. Record cyclic voltammogram for a quasi-reversible heterogeneous electron transfer system with varying scan rates,
   (i) Determine anodic and cathodic peak current ratio.
   (ii) Determine anodic and cathodic peak potential difference.
   (iii) Plot peak current vs square root of scan rates.
   (Use aqueous solution of 10 mM $Fe(NH_4)_2 (SO_4)_2$ + $Fe(NH_4)(SO_4)_2$ + 1 M $HClO_4$)
10. Record the CV of aqueous solution of sulphuric acid (0.5 M) at Pt electrode as working electrode and counter electrode.
   (i) Interpret and explain various peaks and region of the CV and their significance.
   Determine the area and roughness factor of the electrode by Pt oxide region.

*[pre-recorded data for computer simulation may also be shared for visualization analysis and interpretation on MS-Excel]

Laboratory Activities

11. Assembling a simple electrochromic device from household materials and visualization of the colour change of curcumin.
   (https://pubs.acs.org/doi/10.1021/acs.jchemed.2c00176.)

12. Design concentration cells to demonstrate whether
   (i) Iron under the water surface has the same Corrosion Level at any part?
   (ii) Copper Sheets be Galvanized with Zinc without an External Power Supply?
   (https://pubs.acs.org/doi/10.1021/acs.jchemed.0c01408.)

Essential/recommended readings
Theory:

1. Bard, A. J. Faulkner, L. R. Electrochemical Methods: Fundamentals and Applications, 2nd Ed., John Wiley & Sons: New York, 2002.

2. Oldham, K. B., Myland, J. C. and Bond, A. M. Electrochemical Science and Technology: Fundamental and Applications, John Wiley & Sons, Ltd. (2012).
3. Bockris, J. O' M. & Reddy, A. K. N. Modern Electrochemistry 1: Ionics 2nd Ed., Springer (1998).
4. Bockris, J. O' M. & Reddy, A. K. N. Modern Electrochemistry 2B: Electrodics in Chemistry, Engineering, Biology and Environmental Science 2nd Ed., Springer (2001).
5. Bockris, J. O' M., Reddy, A. K. N. & Gamboa-Aldeco, M. E. Modern Electrochemistry 2A: Fundamentals of Electrodics 2nd Ed., Springer (2001).
6. Brett, C. M. A. & Brett, A. M. O. Electrochemistry, Oxford University Press (1993).
7. Koryta, J., Dvorak, J. & Kavan, L. Principles of Electrochemistry John Wiley & Sons: NY (1993).
8. Bagotsky, V.S., Fundamentals of electrochemistry 2nd Ed. Wiley – Interscience, (2006)
9. Hamann, Carl H., Hamneff, Andrew & Vielstich, Wolf., Electrochemistry, 2nd Ed. (2007)

Practical:

1. B. D. Khosla, V. C. Garg, A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. Holze R., (2019) Experimental Electrochemistry: A laboratory Textbook, Wiley-VCH.
3. Elgrishi, N.; Rountree, K. J.; McCarthy, B. D.; Rountree, E. S.; Eisenhart, T. T.; Dempsey, J. L. A Practical Beginner's Guide to Cyclic Voltammetry, *J. Chem. Educ.* **2018**, *95*, *2*, 197–206.
4. Field, R. J.; Schneider, F. W. Oscillating Chemical Reactions and Nonlinear Dynamics, *J. Chem. Educ.* **1989**, *66*, *3*, 195–204.
5. Rozman M, Alif M, Bren U., Lukšič M., Electrochromic Device Demonstrator from Household Materials, *J. Chem. Educ.* 99, 10, 3595-3600.
6. Ling Y., Chen P., **2022**, Wang J., Chen K, Ren H. Design, Implementation, and Evaluation of a Scientific Modeling Course on Concentration Cells, *J. Chem. Educ.* **2021**, 98, 4, 1163-1173

Note: Minimum 6 hands-on exercise to be performed**.**

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SEMESTER VIII

Discipline Specific Elective Courses (Common Pool) applicable for both B.Sc. Life Sciences and B.Sc. Physical Sciences

Discipline Specific Elective Course – 19 (DSE-19)
Fundamentals of Natural Products**

****For syllabus content of Discipline Specific Elective-19: (DSE-19)** "Fundamentals of Natural Products" refer to the syllabus content of **DSE-19** of **B Sc. Life Sciences Programme**.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 20 (DSE-20)
Fundamentals of Medicinal Chemistry**

****For syllabus content of Discipline Specific Elective-20: (DSE-20)** "Fundamentals of Medicinal Chemistry" refer to the syllabus content of **DSE-20** of **B Sc. Life Sciences Programme**.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 21 (DSE-21)
Computational Chemistry**

****For syllabus content of Discipline Specific Elective-21: (DSE-21)** "Computational Chemistry" refer to the syllabus content of **DSE-21** of **B Sc. Life Sciences Programme**.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 22 (DSE-22): Machine Learning and Artificial Intelligence in Chemistry*

***For syllabus content of Discipline Specific Elective-22: (DSE-22)** “Machine Learning and Artificial Intelligence in Chemistry refer to the pool of DSE courses in 4th year syllabus of **B.Sc. (H) Chemistry**.

DISCIPLINE SPECIFIC COURSES Applicable Specifically for B.Sc. Physical Sciences

DISCIPLINE SPECIFIC ELECTIVE COURSE – 23 PS (DSE-23 PS): Crystalline solids: Properties and Methods of Analysis

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Crystalline Solids: Properties and Methods of Analysis (DSE-23 PS)	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	--

Course Objectives

The objectives of this course are as follows:

- To analyse different crystal systems and understand their properties.
- To study Curie's and Curie-Weiss law and its application to paramagnetic and ferromagnetic materials, respectively.
- To understand the principles and application of basic instrumentation techniques.

Learning outcomes

By studying this course, the students will be able to:

- Distinguish between lattice, unit cell, and the 14 Bravais lattices, and understand their symmetry and properties.
- Interpret XRD patterns of NaCl, CsCl, and KCl to deduce structural information.
- Understand the Curie-Weiss law and its application to ferromagnetic materials.
- Analyse and interpretation of experimental data obtained through experimental techniques.

Theory:

Unit 1: Crystalline Solids **(9 Hours)**

Classification and characteristics of crystalline solids, seven crystal systems. Fundamentals of lattice, unit cell and fourteen Bravais lattices. Types of closed-packed structures. Elementary idea of symmetry. Crystal's direction and planes, Miller indices.

Unit 2: Diffraction Methods **(9 Hours)**

Bragg's law and Bragg's conditions. X-ray diffraction pattern of simple cubic systems i.e. NaCl, CsCl, and KCl, Laue method, Crystallite size (Scherrer equation) and Williamson-Hall method to determine lattice strains from diffraction patterns. Elementary idea of Thermogravimetric analysis (TGA).

Unit 3: Electronic Properties and Band Theory of Solids **(6 Hours)**
Introduction- metals, insulators, and semiconductors. Electronic structure, k-space and Brillouin zone, band structure of metals, insulators, and semiconductors.

Unit 4: Magnetic Properties **(6 Hours)**
Magnetic moment, Curie law, Curie-Weiss law, magnetic ordering, exchange Interaction, Hysteresis, anisotropy, paramagnetism, ferromagnetism, ferrimagnetism, antiferromagnetism

Practicals: **Credits: 02**

(Laboratory periods:15 classes of 4 hours each)

1. Preparation of semiconducting TiO_2 /ZnO/ CdSe/ ZnSe/ In_2S_3 and metal nanomaterials (Ag/ Cu/ Ni etc.) by any soft chemical approach (emulsion based, co-precipitation etc.). (Minimum two preparations)
2. Analysis of diffraction pattern obtained from Powder X-ray diffractometer. Identifying crystal phase, diffraction peaks with lattice planes for a given compound*.
3. Determination of approximate crystallite size using the given PXRD pattern of a known compound i.e. TiO_2, ZnO etc by employing Scherer equation*.
4. Determination of lattice strain using Williamson-Hall equation and from the measured PXRD pattern of a known inorganic compound for example, TiO_2, ZnO etc.*
5. Determination of band gap of a semiconducting nanoparticle (in solution) using UV-visible spectrophotometer.
6. Thermogravimetric analysis of a known compound*. (Analysis of the thermal decomposition pattern of a hydrated salt like calcium sulfate pentahydrate, magnesium sulfate heptahydrate, etc.)
7. Determination of congruent composition and temperature of a binary system (e.g. diphenylamine-benzophenone/ Urea-resorcinol system).
8. Analysis of p-XRD data of a given set of Metals/ compounds* (Ag/Au/Cu/NaCl/CsCl) and confirmation of the type of the cubic system corresponding to given species.
9. Demonstrate the Principles, experimental setup, and instrumentation of TGA, and Interpretation of the analytical information from TGA curves*.

*[Diffraction patterns of known sample along with Standard JCPDS file (JCPDS: Joint Committee for Powder Diffraction Studies) be provided to students for analysis]

Essential/recommended readings

Theory:

1. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 5th Edition, Mc Graw Hill Education.
2. Levine I.N. (2009), Physical Chemistry 6th Edition, Mc Graw Hill Education.
3. Pillai S.O., (2022) Solid State Physics 6th Edition, New Age International Publishers.
4. Chakrabarty, (2022) D. K., Solid State Chemistry, 2nd Edition, New Age International Publishers.
5. West, A.R., (2022), Solid State Chemistry and its Applications, 2nd Edition, Wiley Inc.
6. Callister W. D., (2018) Materials Science and Engineering: An Introduction, 10th Edition, Willey Inc.
7. Keer H. V., (Reprint 2005), Principles of the Solid State, New Age International Publishers.

Practical:

1. Cullity, B. D. (2001) *Elements of X-ray Diffraction*, 3rd ed.; Prentice Hall.
2. Hammond, C. (2015) *The Basics of Crystallography and Diffraction*, 4th ed.; Oxford University Press.
3. Snyder, R. L. (1996) Jenkins, R. *Introduction to X-ray Diffractometry*; Wiley: New York.
4. Evans J. S. O., Evans I.R., Structure Analysis from Powder Diffraction Data: Rietveld Refinement in Excel, *J. Chem. Educ.* **2021**, *98, 2, 495-505*.
5. Hulien M.L., Lekse J.W., Rosmus K. A., Devlin K. P., Glenn J.R., Wisneski S. D., Wildfong P., Lake C. H., MacNeil J. H.Aitken J. A., An Inquiry-Based Project Focused on the X-ray Powder Diffraction Analysis of Common Household Solids, *J. Chem. Educ.* **2015**, *92, 12, 2152-2156*.
6. Bentley A. K., Farhoud M, Ellis A. B., Lisensky G.C., Nickel A-Marie L, Crone W. C., Template Synthesis and Magnetic Manipulation of Nickel Nanowires, *J. Chem. Educ.* **2005**, *82, 5, 765-768*.
7. Oliveira M. L., Pagung E., Lorenzini L., Neves T.R., Pereira J.R.P., Ferreira S. A. D., Freitas M. B. J.G. de, Moura P. R.G., Lelis M. F. F., Synthesis of Iron Oxide Nanoparticles and their Application in Photo-Fenton Process: An Undergraduate Experiment in Chemistry, *J. Chem. Educ.* **2025**, *102, 1590-1597*.
8. How to Characterize 4−90nm Size Gold Nanospheres with Experimental and Simulated UV−Vis and a Single SEM Image, *J. Chem. Educ.* **2023**, *100, 1589-1596*.
9. https://www.icdd.com/ (International Centre for Diffraction Data).

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.-

DISCIPLINE SPECIFIC ELECTIVE COURSE – 24 PS (DSE-24 PS)

Coordination Chemistry, Reaction Mechanism and Spectral properties

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Coordination Chemistry, Reaction Mechanism and Spectral properties (DSE-24 PS)	**04**	**02**	**--**	**02**	Class12th with Physics, Chemistry, Mathematics	**--**

Course Objectives

The Learning Objectives of this course are as follows:

- Solve problems from the basic and advanced concepts of transition metal chemistry
- Apply different bonding theories to explain the interaction between transition metals and ligands and predict the shape, stability, and optical and magnetic properties of complexes
- Design the most possible products and choose appropriate reaction condition to obtain the desired products in coordination compounds
- Appraise some natural phenomenon where reactions of coordination compounds are happening inside the human body and in plants enabling them to improve individual and societal health as well as environment.

Learning Outcomes

By the end of this course, students will be able to:

- Understand the advance theories to explain bonding in complexes.
- Attain knowledge of reaction mechanism of complexes.
- Understand the spectroscopic techniques to study structure and bonding in complexes.
- Develop skills in the scientific method of planning, developing, conducting, reviewing and reporting experiments.
- Understand concepts of industrial catalysis which will help them to explore new innovative areas of research.

Theory:

Unit 1: Ligand Field/ Molecular Orbital Theory (MOT) of Coordination Compounds (10 Hours)

Limitations of CFT, Crystal field to ligand field, σ and π bonding and energy diagrams of octahedral, tetrahedral, square planar complexes, effect of ligand group orbitals on Δ, effect of charge of metal on Δ, spectrochemical series comparison from different theories.

Unit 2: Reaction Mechanism (10 Hours)

Reaction mechanisms of metal complexes, Nucleophilic substitution reactions in octahedra complexes and their mechanisms, hydrolysis reactions, water exchange reactions, trans effect and its application, electron transfer reactions, inner sphere and outer sphere mechanisms, mixed valence complexes, redox reactions of metal complexes in excited states, role of spin-orbit coupling, life-times of excited states in these complexes.

Unit 3: Electronic Transitions and Selection Rules (5 Hours)

Spin and Laporte selection rules of transitions, charge transfer transitions, LMCT and MLCT transitions, Intervalence charge transfer and inter ligand π-π^* charge transfer.

Unit 4: Spectral Properties (5 Hours)

Nephelauxetic series, Orgel and Tanabe-Sugano diagrams, spin cross over, Jahn-Teller Distortions and Spectra,

Practicals: Credits: 02

(Laboratory periods:15 classes of 4 hours each)

1. Estimation of Ca^{2+} in solution by (substitution method) using Erio-chrome black-T as indicator.
2. Estimation of Ca^{2+} /Mg^{2+} in drugs/ Milk/ Biological samples by Back titration.
3. Complexometric estimation of Zn^{2+} using Xylenol orange as indicator.
4. Complexometric estimation of Al^{3+} using Erio-chrome black-T as indicator.
5. Complexometric estimation of mixture of Zn^{2+} and Mg^{2+} in a sample solution using Xylenol orange and Eriochrome black-T as indicator
6. Complexometric estimation of mixture of Al^{3+} and Mg^{2+} in a sample solution using masking agent.
7. Estimation of $BaSO_4$ by EDTA back titration using Eriochrome black-T as indicator.
8. Measurement of 10 Dq by spectrophotometric method.
9. Verification of Spectrochemical series.
10. Preparation of acetylacetonato complex of Cu^{2+} and Fe^{3+}. Determine λ_{max} of the complex.
11. Synthesis of ammine complex of Ni^{2+} and its ligand exchange reaction such as acetylacetone, DMG, glycine by substitution method.

Essential/recommended readings
Theory:

1. Huheey, **J.** E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity,** Pearson Education.
2. Cotton, F.A.; Wilkinson, G. (1999), **Advanced Inorganic Chemistry,** Wiley-

VCR.
3. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry,** 5th Edition, Pearson.
4. B.E. Douglas, D.H. McDaniel and J.J. Alexander, **Concepts and Models of Inorganic Chemistry**, JohnWiley,1993, 3rd ed.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. {1989}, **Vogel's Textbook of Quantitative Chemical Analysis,** John Wiley and Sons,
2. Harris, D. C.; Lucy, C. A.{2016}, **Quantitative Chemical Analysis,** 9th Edition, Freeman and Company.
3. Day, R. A.; Underwood, A. L. {2012}, **Quantitative Analysis,** Sixth Edition, PHI Learning Private Limited.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

List of Instruments/Software required for Implementation of Fourth year Course of Study for each College

1. UV- Vis Spectrophotometer
2. Table top IR Spectrophotometer
3. ChemDraw, GaussView6/ GaussView5 and Gaussian 16/Gaussian 09 Software
4. Access to p-XRD NMR Spectrophotometer in Department of Chemistry/USIC
5. Rota Evaporator
6. Sonicator
7. Cyclic Voltammeter/ Potentiostate-Galvanostate

COURSES OFFERED BY DEPARTMENT OF CHEMISTRY

B Sc. Life Sciences

Undergraduate Programme of study

(with Chemistry as the Major Disciplines)

Semester-wise Distribution of Discipline Specific Core (DSC) Courses

DISCIPLINE CORE COURSES –02 (4 Credits each)			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
VII	DSC-19	Chemistry of d- and f- block elements, Advanced Organic Spectroscopy and Elements of Quantum Chemistry	T=3 P=1
VIII	DSC-20	Organometallic Chemistry and Bio-catalysis, Application of Reagents in Organic Synthesis and Crystalline Solids & their Magnetic Properties	T=3 P=1

DISCIPLINE SPECIFIC ELECTIVE COURSES – (4 Credits each)			
SEMESTER	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
VII	**Common Pool of DSE Courses applicable for both B.Sc. Physical Sciences and B.Sc. Life Sciences**		
	DSE-14	Industrial Chemicals and Environment	T=2 P=2
	DSE-15	Advanced Stereochemistry	T=2 P=2
	DSE-16	Reactive Intermediates of Organic Chemistry	T=2 P=2
	DSE-17	Molecular Spectroscopy and Structural Analysis	T=2 P=2
	DSE Course applicable specifically for B.Sc. Life Sciences		
	DSE-18 LS	Nanomedicine and Nanosensing	T=2 P=2
VIII	**Common Pool of DSE Courses applicable for both B.Sc. Physical Sciences and B.Sc. Life Sciences**		
	DSE-19	Fundamentals of Natural Products	T=2 P=2
	DSE-20	Fundamentals of Medicinal Chemistry	T=2 P=2
	DSE-21	Computational Chemistry	T=2 P=2
	DSE-22	Machine Learning and Artificial Intelligence in Chemistry*	T=2 P=2
	DSE Course applicable specifically for B.Sc. Life Sciences		
	DSE-23 LS	Bioelectrochemistry	T=2 P=2
	DSE-24 LS	Nanomaterials and their Biological Applications	T=2 P=2

*** For syllabus content of DSE-22: "**Machine Learning and Artificial Intelligence in Chemistry" refer to DSE syllabus of B.Sc. (H) Chemistry.

Note: A student, studying in 4th year of B.Sc. Physical Science/Life Science Programme, desirous of opting any *Discipline Specific Elective* (DSE) Course from progression of DSE courses available in Semester III-VI of the programme, may be allowed to opt the same in the VIIth or VIIIth semester.

Semester VII

DISCIPLINE-SPECIFIC CORE COURSE - 19 (DSC-19): Chemistry of d- and f- block elements, Advanced Organic Spectroscopy and Elements of Quantum Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemistry of d- and f- block elements, Advanced Organic Spectroscopy and Elements of Quantum Chemistry **(DSC-19)**	**04**	**03**	**-**	**01**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To provide thorough knowledge about the d- and f- block elements with respect to the general group trends, physical and chemical properties of these elements.
- To impart the knowledge about synthetic methods and principles of chromatography.
- Understanding spectroscopic techniques and their application in the structural elucidation of organic molecules.
- To familiarize the students with the postulates of quantum chemistry
- To explain how to apply the postulates to derive equations for various models and extend to the hydrogen atom and hydrogen-like atoms.
- To provide an insight into the MO approach of chemical bonding.

Learning outcomes

By studying this course, students will be able to:

- Understand the important properties of transition metals, lanthanoids, and actinoids
- Use Latimer diagrams to predict and identify species which are reducing, oxidizing and tend to disproportionate and calculate skip step potentials.
- Develop understanding on the principles of synthesis of Inorganic compounds and chromatographic separation of metal ions.

- Develop understanding of the basic principles of NMR spectroscopy, such as chemical shift, coupling constant, and anisotropy, and describe how they are affected by molecular structure, and identify organic compounds by analysis and interpretation of spectral data.
- Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle
- Understand Schrodinger equations for different types of systems
- Analyse different wave functions and probability distribution curves.

UNIT- 1: Chemistry of Transition Elements (15 Hours)

General group trends with special reference to electronic configuration, colour, variable valency, magnetic properties, catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer diagrams), Frost diagrams of Mn and Cr. A brief discussion of differences between the first, second and third transition series

A brief discussion of electronic configuration, oxidation states, colour, spectral and magnetic properties. Lanthanoid contraction (causes and effects), separation of lanthanoids by ion exchange method.

UNIT-2: Spectroscopic Techniques in Organic Chemistry (15 Hours)

Recapitulation of the Spectroscopic Techniques (UV- VIS, IR, and ^{1}H NMR)

Carbon-NMR Spectroscopy
Resolution and multiplicity of ^{13}C NMR, ^{1}H-decoupling, noise decoupling, broadband decoupling; Deuterium, fluorine, and phosphorus coupling; NOE signal enhancement, Off resonance, proton decoupling, Structural applications of CMR. DEPT and general introduction about 2D NMR.

Mass Spectrometry
Theory, Fourier transform mass spectrometry instrumentation (FTMS); Unit mass and molecular ions; Important terms singly, doubly/multiple charged ions, metastable peak, base peak, isotopic mass peaks, relative intensity; Recognition of M^+ ion peak; Nitrogen rule; Rule of 13; Ionization methods (EI and ESI). General fragmentation rules: McLafferty rearrangement, ortho effect.

ESR Spectroscopy
Basic Principles and applications for organic Compounds.

Structure Elucidation
Structure elucidation of Organic Compounds Using UV, IR, NMR, and Mass Spectra.

UNIT -3: Quantum Mechanics: An overview (6 Hours)

Recapitulation of postulates of quantum mechanics and quantum mechanical operators; Linear and Hermitian operators, commutation rules and Uncertainty principle.

Particle in a 1–D box, quantization of energy levels, zero-point energy, wave functions, probability distribution functions, nodal properties, and qualitative extension to 3-D box (Final Energy expression only) and the concept of degeneracy.

UNIT -4: Quantum Mechanical treatment: Atoms and Molecules (9 Hours)

Vibrational and Rotational Motion: Schrödinger equation of a linear harmonic oscillator and brief qualitative discussion of its results. Schrödinger equation of a rigid rotator and brief qualitative discussion of its results.

Qualitative treatment of hydrogen atom; setting up of Schrödinger equation in spherical polar coordinates, radial part and quantization of energy (only final energy expression). Qualitative idea of indistinguishability of the electrons and their intrinsic spin, spatial and spin wavefunctions, Pauli's Exclusion principle.

Linear Combination of Atomic Orbitals (LCAO), salient features of MO theory and setting up of wavefunction of $\boldsymbol{H_2}$ molecule.

Practical: Credits: 01
(Laboratory periods: 15 classes of 2 hours each)

PART A: INORGANIC CHEMISTRY

Inorganic Preparations

1. Potassium aluminium sulphate $KAl(SO_4)_2.12H_2O$ (potash alum} or
   Potassium chromium sulphate $KCr(SO_4)_2.12H_2O$ (chrome alum}.
2. Manganese phosphate and
3. Sodium peroxoborate

Paper chromatographic separation of following metal ions (minimum two exercise to be done):

4. Ni(II) and Co(II)
5. Cu(II) and Cd(II)
6. Fe(III) and Al(III)

PART B: ORGANIC CHEMISTRY

(Spectra to be provided wherever required)

7. Diels-Alder reaction between maleic anhydride and anthracene and identification of the product using IR and NMR Spectroscopy.
8. Knoevenagel condensation between aromatic aldehydes (benzaldehyde/*p*-nitrobenzaldehyde) and active methylene compounds (malononitrile/ethyl cyanoacetate/ diethylmalonate) and identification of the product using IR and NMR Spectroscopy.
9. Differentiate between maleic and fumaric acid solutions by UV spectroscopy.
10. Demonstration of the separation of the mixture of *p*-nitrophenol and *o*-nitrophenol by column chromatography and their characterization by melting point and spectroscopic techniques.

PART C: PHYSICAL CHEMISTRY

11. Plot the radial wavefunctions and probability distribution for H atom's 1s, 2s, 2p orbitals using software, i.e. MS-EXCEL.
12. (i) Draw probability plots for a particle in a 1-dimensional box for different values of quantum number n- commenting on the number of points of zero probability and then correlating them with the correspondence principle.
    (ii) Calculation of the bond length of conjugated dye molecules (i.e., cyanine/β-carotene) using a particle in 1D box model using MS-EXCEL.

Hands-on/ Instruction Mode:

13. (i) Carry out the calculation of various average values ($\langle x \rangle$, $\langle p \rangle$, $\langle x^2 \rangle$ and $\langle p^2 \rangle$) for the simple harmonic oscillator.
    (ii) Setting up of Schrödinger equation of Many-electron atoms and cite limitations to carry out an exact solution of the problem.
14. Demonstrate the variational treatment of the hydrogen molecule ion and also exhibit Valence bond and Molecular orbital (LCAO) treatment of the hydrogen molecule.

Essential/recommended readings

Theory

1. Lee, J.D.(2010), Concise lnorganic Chemistry, Wiley lndia.
2. Huheey,J.E.; Keiter,E.A.; Keiter;R.L.; Medhi,O.K.(2009), lnorganicChemistry-Principles of Structure and Reactivity, Pearson Education.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
4. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.
5. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons.
6. Cotton, F.A.; Wilkinson, G. (1999), Advanced Inorganic Chemistry, Wiley-VCH.
7. Das, A. K.; Das, M. (2014), Fundamental Concepts of Inorganic Chemistry, 1st Edition, Volume 1-3, CBS Publishers & Distributors Pvt. Ltd.
8. S. K. Ghuman, A. Sakthivel, D. T. Masram, M. Sathiyendiran, (2017) Electronic and Magnetic properties of transition and inner transition elements and their complexes, Nova Science Publishers, New York.
9. Chandrashekhar,V. (2005}, Inorganic and Organometallic Polymers, 5th Edition, Springer Publications.
10. Kemp, W. Organic Spectroscopy 3rd Ed., W. H. Freeman & Co. (1991).
11. Silverstein, R. M., Bassler, G. C. & Morrill, T. C. Spectroscopic Identification of Organic Compounds. John Wiley & Sons (1981).
12. Pavia, D. L.; Lampmann, G. M.; Kriz, G. S.; Vyvyan, J. R. Introduction to Spectroscopy. Cengage Learning (2014).
13. Organic Structures from spectra; L. D. Field, S. Sternhell and J R Kalman, John Wiley & Sons Ltd., 2007
14. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.
15. Bakhshi, A. K. & Thakral P., Quantum Chemistry Simplified Vidyavani Foundation: New Delhi (2025).
16. House, J.E. (2004), Fundamentals of Quantum Chemistry, 2nd Edition, Elsevier.
17. McQuarrie, D.A. (2016), Quantum Chemistry, Viva Books.

18. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
19. Atkins, P.W.; Friedman, R. (2010), Molecular Quantum Mechanics, 5th Edition, Oxford University Press.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons,
2. Harris, D. C.; Lucy, C. A. (2016), Quantitative Chemical Analysis, 9th Edition, Freeman and Company.
3. Day, R. A.; Underwood, A. L. (2012), Quantitative Analysis, Sixth Edition, PHI Learning Private Limited.
4. Marr, G.; Rockett, B.W. (1972), Practical Inorganic Chemistry, Van Nostrand Reinhold.
5. Vogel, A. I. (2012). Quantitative Organic Analysis, Part 3, Pearson Education.
6. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
7. Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A. R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
8. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
9. Morrill, L. A., Kammeyer, J. K., & Garg, N. K. (2017). Spectroscopy 101: A practical introduction to spectroscopy and analysis for undergraduate organic chemistry laboratories. *J. Chem. Educ.* 94 (10), 1584-1586.
10. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.
11. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books(2008).
12. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
13. Steiner, E. The Chemical Maths Book Oxford University Press (1996).
14. Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).
15. Levie, R. de, How to use Excel in analytical chemistry and in general scientificdata analysis, Cambridge Univ. Press (2001) 487 pages.
16. Noggle, J. H. Physical Chemistry on a Microcomputer. Little Brown & Co. (1985).

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

Semester VIII

DISCIPLINE SPECIFIC CORE COURSE - 20 (DSC-20): Organometallic Chemistry and Bio- catalysis, Application of Reagents in Organic Synthesis and Crystalline Solids & their Magnetic Properties

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Organometallic Chemistry and Bio-catalysis, Application of Reagents in Organic Synthesis and Crystalline Solids & their Magnetic Properties **(DSC-20)**	**04**	**03**	**--**	**01**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To imparts basic knowledge of Organometallic compounds and catalysis,
- To enrich students with the knowledge of various types of bonding and structure of organometallic compounds and biocatalysts.
- To impart the theoretical and practical knowledge of catalysts with the view of their industrial applications.
- To facilitate chemical transformations by providing the necessary conditions and catalysis.
- To analyze different crystal systems and understand their properties.
- To study Curie's and Curie-Weiss law and its application to paramagnetic and ferromagnetic materials, respectively.
- To understand the principles of powder-XRD and structural analysis of solids.

Learning outcomes

By studying this course, the students will be able to:

- Understand the role of catalyst in industrial applications.
- Gain sound knowledge of various types of catalyst.
- Get skilled in the scientific method of planning, developing, conducting, reviewing and reporting experiments.

- Get skilled concepts of industrial catalysis which will help them to explore new innovative areas of research
- Understand various reducing agents, oxidizing agents, and their applications in organic synthesis.
- Understand the conversion of specific functional groups without affecting others and maximize yields and selectivity for the desired products
- Analyze the distingtion between lattice, unit cell, and the 14 Bravais lattices, and understand their symmetry and properties.
- Interpret XRD patterns of NaCl, CsCl, and KCl to deduce structural information.
- Understand the Curie-Weiss law and its application to ferromagnetic materials.
- Interpret data obtained from instrumental techniques for structural analysis of crystalline solids.

UNIT- 1: Organometallic Chemistry and Biocatalysis (15 Hours)

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, sigma, pi and multicentre bonds), Structure and bonding of methyl lithium and Zeise's salt, Structure and bonding of ferrocene, mononuclear and polynuclear carbonyls of 3d metals, 18-electron rule as applied to carbonyls, π-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of infrared spectroscopy data to explain the extent of back bonding. Bio-organometallic chemistry: Conjugates of ferrocene with biomolecules such as amino acid and protein, and their applications. Organometallic complexes as radiopharmaceuticals.

Key aspects of Bio-catalysis, Variables affecting bio-catalysis such as temperature, pH, solvent etc., Enzyme catalyzed reactions and their Kinetics. Detailed study of biocatalyst in the metabolism of Hydrogen, carbon, and sulfur. Nanobiocatalysis.

UNIT- 2: Synthesis and Applications of Reagents in Organic Synthesis (15 Hours)

Synthesis and applications of BuLi, Grignard, organoaluminium, and organozinc reagents**.**

Triacetoxyborohydride, Lead Acetate, Phenyliodine (III) diacetate (PIDA), DCC, Tamao-Fleming Oxidation; Dimethyldioxirane (DMDO) Oxidation; DMSO (Barton modification & Swern Oxidation); Oxidation of organic compounds using thallium nitrate, selenium dioxide, phase transfer catalyst, crown ethers, $KMnO_4$, PCC, OsO_4, CrO_3, $K_2Cr_2O_7$**.**

Applications of hydroboration (reductions, oxidations, and carbonylation): Diborane, 9-BBN.

UNIT- 3: Crystalline Solids (11Hours)

Classification and characteristics of crystalline solids, seven crystal systems. Fundamentals of lattice, unit cell and fourteen Bravais lattices. Types of closed-packed structures. Elementary idea of symmetry. Crystal's direction and planes, Miller indices. X-ray diffraction, Bragg's law. PXRD diffraction pattern of NaCl, CsCl, and KCl,

UNIT -4: Magnetic Properties of Solids (4 Hours)

Magnetic moment, Curie law, Curie-Weiss law, mechanism of magnetic ordering, exchange Interaction, domain theory, hysteresis, anisotropy, paramagnetism, ferromagnetism, ferrimagnetism, antiferromagnetism.

Practicals: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

PART A: INORGANIC CHEMISTRY

1. Synthesis of "Zeolite A" catalyst.
2. Zeolite Hydrogen-Y or dil.HC1/dil.H_2SO_4 as a Catalyst for the Preparation of an Ester.
3. Catalytic Synthesis of biaryl.
4. Catalytic Transfer Hydrogenation of Castor Oil

PART B: ORGANIC CHEMISTRY

Identification of the product based on Melting point and spectroscopic techniques (IR, ^{1}HNMR, and ^{13}C NMR spectroscopy, data to be provided).

5. Synthesis of 1,2,3,4-tetrahydrocarbazole from cyclohexanone.
6. Reduction of *p*-nitrobenzaldehyde using $NaBH_4$
7. Synthesis of 2,3-diphenylquinoxaline from benzil and *ortho*-phenylenediamine.
8. Oxidation of benzyl alcohol by $KMnO_4$.

PART C: PHYSICAL CHEMISTRY

9. Analysis of diffraction pattern obtained from Powder X-ray diffractometer. Identifying crystal phase, diffraction peaks with lattice planes for a given compound.
10. Analysis of p-XRD data of a given set of Metals/ compounds* (Ag/Au/Cu/NaCl/CsCl) and confirmation of the type of the cubic system corresponding to given species.
11. Determination of approximate crystallite size using the measured PXRD pattern of a known inorganic compound i.e. TiO_2, ZnO etc by employing Scherer equation.
12. Determination of lattice strain using Williamson-Hall equation and from the measured PXRD pattern of a known inorganic compound for example, TiO_2, ZnO etc.*

*[Diffraction patterns of known sample along with Standard JCPDS file (JCPDS: Joint Committee for Powder Diffraction Studies) be provided to students for analysis]

Essential/recommended readings
Theory:

1. Huheey, J. E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education.
2. Cotton, F.A.; Wilkinson, G. (1999), Advanced Inorganic Chemistry, Wiley-VCR.
3. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.
4. Jens Hagen (2015) Industrial Catalysis: A Practical Approach Wiley VCR Verlag GmbH&Co
5. Gérard Jaouen,(2006) Bioorganometallics, Wiley-VCH Verlag GmbH & Co.
6. Carruthers, W. Modern Methods of Organic Synthesis. Cambridge University Press (1996).
7. Carey, F.A. & Sundberg, R. J. Advanced Organic Chemistry, Parts A & B, Plenum: U.S. (2004).

8. Jonathan Clayden, Nick Greeves, Stuart Warren. Organic Chemistry. Oxford. (2000)
9. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 5th Edition, Mc Graw Hill Education.
10. Levine I.N. (2009), Physical Chemistry 6th Edition, Mc Graw Hill Education.
11. Pillai S.O., (2022) Solid State Physics 6th Edition, New Age International Publishers.
12. Chakrabarty, (2022) D. K., Solid State Chemistry, 2nd Edition, New Age International Publishers.
13. West, A.R., (2022), Solid State Chemistry and its Applications, 2nd Edition, Wiley Inc.
14. Callister W. D., (2018) Materials Science and Engineering: An Introduction, 10th Edition, Willey Inc.
15. Keer H. V., (Reprint 2005), Principles of the Solid State, New Age International Publishers.

Practical:

1. Williams, D. J.; Huck, B. E.; Wilkinson, A. P. First-Year Undergraduate Laboratory Experiments with Zeolites Chem. Educator 2002, 7, 33-36.
2. Coker, E. N.; Davis, P. J.; Experiments with Zeolites at the Secondary-School Level: Experience from The Netherlands Journal of Chemical Education 1999, 76, 10, 1417.
3. Hanson RW. Catalytic transfer hydogenation reactions for undergraduate practical programs. J Chem Educ. 2009, 74, 430.
4. Alwaseem H, Donahue CJ, Marincean S. Catalytic transfer hydrogenation of castor oil. J Chem. Educ. 2014; 91, 575-8.
5. Ahluwalia, V. K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
6. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
7. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
8. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi
9. Cullity, B. D. (2001) *Elements of X-ray Diffraction*, 3rd ed.; Prentice Hall.
10. Hammond, C. (2015) *The Basics of Crystallography and Diffraction*, 4th ed.; Oxford University Press.
11. Snyder, R. L. (1996) Jenkins, R. *Introduction to X-ray Diffractometry*; Wiley: New York.
12. Hulien M.L., Lekse J.W., Rosmus K. A., Devlin K. P., Glenn J.R., Wisneski S. D., Wildfong P., Lake C. H., MacNeil J. H.Aitken J. A., An Inquiry-Based Project Focused on the X-ray Powder Diffraction Analysis of Common Household Solids, *J. Chem. Educ.* 2015, *92, 12, 2152-2156.*
13. Evans J. S. O., Evans I.R., Structure Analysis from Powder Diffraction Data: Rietveld Refinement in Excel, *J. Chem. Educ.* 2021, *98, 2, 495-505*.
14. https://www.icdd.com/ (International Centre for Diffraction Data)

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SEMESTER VII

Common Pool of Discipline Specific Elective Courses applicable for both B.Sc. Life Sciences and B.Sc. Physical Sciences

DISCIPLINE SPECIFIC ELECTIVE COURSE – 14 (DSE-14): Industrial Chemicals and Environment

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Industrial Chemicals and Environment (DSE-14)	**04**	**02**	**--**	**02**	Class12th with Physics, Chemistry Biology	**--**

Course Objectives

The objectives of this course are as follows:

The objective of this course is to make students aware about the intricate relationship between industrial processes, the production and use of chemicals, and their profound impact on the environment. Manufacturing, applications, analysis and hazards of the Inorganic Chemicals. Air and Water pollution, control measures for Air and Water Pollutants, Effluents, waste water treatment and Environment.

Learning Outcomes

By studying this course, the students will be able to:

- Understand manufacturing processes, handling and storage of inorganic chemicals.
- Realize hazardous effects of the inorganic chemicals on human beings and vegetation.
- Understand composition of air, various air pollutants, effects and control measures of air pollutants.
- Understand different sources of water, water quality parameters, impacts of water pollution, industrial effluents and water treatment.

UNIT- 1: Inorganic Chemicals: (8 Hours)

Inorganic Chemicals: Manufacture, applications, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potassium dichromate and potassium permanganate

UNIT- 2: Environment and Its Segments **(4 Hours)**

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur. Major regions of atmosphere, chemical and photochemical reactions in atmosphere.

UNIT- 3: Air Pollution and its Effects **(8 Hours)**

Air pollutants; types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Major sources of air pollution, Pollution by SO_2, CO_2, CO, NO, H_2S and other foul smelling gases, methods of estimation of CO, NOT, SOA and control procedures, Effects of air pollution on living organisms and vegetation, Greenhouse effect and Global warming, Environmental effects of ozone, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, Air pollution control, Settling Chambers, Venturi Scrubbers, Cyclones, Electrostatic Precipitators (ESPs).

UNIT-4: Water Pollution **(10 Hours)**

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological cycle and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro fertilizer. Water quality parameters for wastewater, industrial water and domestic water.

Practicals: **Credits: 02**

(Laboratory periods: 15 classes of 4 hours each)

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD).
3. Determination of Biological Oxygen Demand (BOD).
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples ($CO_3^{2-,}$ HCO_3^-) using double titration method.
7. Measurement of dissolved CO_2 in water samples.
8. Determination of hexavalent Chromium Cr(VI) concentration in tannery wastes/waste water sample using UV-Vis spectrophotometry technique.
9. Preparation of borax/ boric acid

Essential/recommended readings
Theory:

1. Manahan, S.E. (2017),EnvironmentaI Chemistry, CRC Press
2. Buchel, K.H.; Moretto, H.H.; Woditsch, P.(2003),Industrial Inorganic Chemistry, Wiley-VCH.
3. De, A.K.(2012), Environmental Chemistry, New Age International Pvt., Ltd.
4. Khopkar, S.M.(2010), Environmental Pollution Analysis, New Age International Publisher.

Practical:

1. Vowles, P.D.; Connell, D.W. (1980), Experiments in Environmental Chemistry: A Laboratory Manual, Vol.4, Pergamon Series in Environmental Science.
2. Gopalan, R.; Anand, A.; Sugumar R.W. (2008),A Laboratory Manual for Environmental Chemistry, I. K. International.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 15 (DSE-15): Advanced Stereochemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Stereochemistry **(DSE-15)**	**04**	**02**	**--**	**02**	Class12th with Physics, Chemistry	-

Course Objectives

To provide a comprehensive understanding of molecular symmetry, isomerism, and chirality, including their applications in organic reactions.

Learning outcomes

By studying this course, the students will be able to understand:

- The basic concept of chirality in molecules due to their spatial arrangement of atoms that leads to chiroptical properties.
- The three-dimensional arrangement of atoms in a molecule can lead to distinct physical and chemical properties, particularly for stereoisomers. Understanding stereochemistry is crucial for designing effective drugs, predicting reaction outcomes, and developing new materials.
- That, stereochemistry significantly impacts drug action, biological processes, and chemical reactions, influencing factors like drug efficacy, selectivity, and even the rate of chemical reactions.

UNIT -1: (15 Hours)

Stereoisomerism: Chiral (stereogenic) centre, principle of axial and planar chirality; Stereochemistry and configurations of biphenyls (atropisomerism), bridged biphenyls, ansa compounds and cyclophanes, allenes, spiranes, alkylidine cycloalkanes, adamantanes, catenanes and helicity.

UNIT -2: (5 Hours)

Topicity and prostereoisomerism: Topicity of ligands and faces and their nomenclature; Stereogenicity, chirogenicity, and pseudoasymmetry, stereogenic and prochiral centres.

UNIT-3: (3 Hours)

Asymmetric induction: Cram's, Prelog's, and Felkin-Ahn model.

Unit-4: (7 Hours)

Cyclostereoisomerism: Configurations, conformations and stability of cyclohexanes (di-, and tri-substituted), cyclohexenes, cyclohexanones, decalin.
Applications of ORD and CD to Stereochemical Problems

Practicals: **Credits: 02**
(Laboratory periods:15 classes of 4 hours each)

1. E/Z and Cis-Trans Isomerism of 2,3-dimethyl-2-butene by ball and stick models
2. Identification of Chiral Centres and Diastereomers by ball and stick models
3. Bromination of cis and trans stilbene
4. Addition of Bromine to trans-Cinnamic Acid
5. Photoinduced isomerization of *cis*-Stilbene to *trans*-Stilbene and *vice versa*
6. Photocatalytic/ thermal isomerization of maleic acid to fumaric acid.[3]
7. Preparation of stilbene dibromide by bromination of *trans*-stilbene.
8. Determination of optical rotation of sucrose, glucose, and fructose using polarimetry and determining their concentration.
9. Two-step synthesis of acetonide from benzil and analysis of its stereochemistry using NMR and IR spectroscopy
10. Determination of specific rotation of (R)-limonene and (S)-limonene using Polarimeter.
11. Proline-catalyzed aldol reaction of cyclohexanone with nitro-substituted benzaldehydes.[5]
12. Preparation of hydroxybenzoin by pinacol coupling reaction: Investigating the Diastereoselectivity of Benzaldehyde Pinacol Coupling Mediated by Al-KOH in Aqueous Media: Affording *meso*- and dl-Hydrobenzoin.[4]

Essential/recommended readings
Theory:

1. Eliel, E. L. (2000), Stereochemistry of Carbon Compounds, Tata McGraw-Hill.
2. Nasipuri, D. (2018), Stereochemistry of Organic Compounds: Principles and Applications, 4th Edition, New Age International

Practical:

1. Microscale Organic Laboratory (Multistep and Multiscale Syntheses). By Dana W. Mayo, Ronald M. Pike, David C. Forbes. 2011
2. Green Organic Chemistry: Strategies, Tools, and Laboratory Experiments, Kenneth M. Doxsee, James E. Hutchison. Thomson-Brooks/Cole, 2004
3. The photochemical isomerization of maleic to fumaric acid: an undergraduate organic chemistry experiment. Albert J. Castro, Suzanne R. Ellenberger, and James P. Sluka. *J. Chem. Edu.* 1983, *60* (6), 521 (DOI: 10.1021/ed060p52)
4. Using ^{1}H NMR Spectroscopy to Investigate the Diastereoselectivity of Benzaldehyde Pinacol Coupling Mediated by Al-KOH in Aqueous Media: An Undergraduate Lab Experiment Involving a Green Carbon–Carbon Bond-Forming Reaction Affording *meso* and dl-Hydrobenzoins. Shahrokh Saba; Isabella Fante; James A. Cordero Jr. *J. Chem. Educ.* 2025, 102, 2, 847–851) doi.org/10.1021/acs.jchemed.4c01379
5. Proline-catalyzed asymmetric reactions. List, Benjamin. *Tetrahedron*. 2002, 58 (28): 5573–5590. doi:10.1016/S0040-4020(02)00516-1

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 16 (DSE-16): Reactive Intermediates of Organic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reactive Intermediates of Organic Chemistry **(DSE-16)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**-**

Course Objectives

The objectives of this course are as follows:

To learn and understand the involvement of intermediates, their role in reaction mechanisms, predict their behavior, and apply this knowledge to organic synthesis. Also, to learn and understand the orbital interactions (Woodward-Hoffmann rules) in concerted reactions.

Learning outcomes

By studying this course, the students will be able to:

- Understand the structure-reactivity pattern of reactive intermediates involved in organic reactions.
- Analyse the mechanism of organic reactions involving reactive intermediates and apply these reactions in organic synthesis

Unit 1: Carbocations and Carbanions (11 Hours)

Difference between classical and non-classical carbocations. Introduction of neighboring group participation (NGP), ion-pairs, molecular rearrangements in acyclic, monocyclic, and bicyclic systems, stability and reactivity of bridgehead carbocations.

Generation, structure and stability, ambident ions and their general reactions; HSAB principle and its applications.

Unit 2: Carbenes and Nitrenes (12 Hours)

Structure of carbenes, generation of carbenes, addition and insertion reactions, rearrangement reactions of carbenes such as Wolff rearrangement, generation and reactions of ylid by carbenoid decomposition. Examples of inter/intramolecular insertions.

Structure of nitrene, generation and reactions of nitrene and related electron-deficient nitrogen intermediates, Curtius, Hoffmann, Schmidt, Beckmann rearrangement reactions.

Unit 3: Ylides **(2 Hours)**
Chemistry of Phosphorus and Sulfur ylides – Wittig and related reactions, Peterson olefination.

Unit 4: **Radicals** **(5 Hours)**
Generation of radical intermediates and their addition to: i) on alkenes, alkynes (inter & intramolecular) for C-C bond formation and Baldwin's rules. ii) fragmentation and rearrangements. Name reactions involving radical intermediates, such as Barton deoxygenation and decarboxylation, McMurry coupling.

Practicals: **Credits: 02**
(Laboratory periods:15 classes of 4 hours each)
(Experiments 1 and 2 are compulsory)

1. Separation, purification, and identification of binary mixtures of organic compounds (neutral and acidic; neutral and basic) using chemical methods and preparation of a suitable crystalline derivative for both the components.
2. **Two-step synthesis**

   2.1 ***To carry out the synthesis of triacetoxybenzene***
   Step 1: Synthesis of *p*-benzoquinone from hydroquinone using $KBrO_3$ and
   Step 2: Synthesis of Triacetoxybenzene from *p*-benzoquinone.

   2.2 ***To carry out the synthesis of p-acetamido benzene sulphonamide***
   Step 1: Synthesis of *p*-Acetamido benzene sulfonyl chloride from acetanilide and
   Step 2: Synthesis of *p*-Acetamido benzene sulphonamide from *p*-Acetamido benzene sulfonyl chloride.

   2.3 ***To carry out the synthesis of benzopinacolone***
   Step 1: Synthesis of benzopinacol from benzophenone
   Step 2: Synthesis of benzopinacolone from benzopinacol *via* pinacol-pinacolone rearrangement.

Essential/recommended readings
Theory:

1. Carey and R. A. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5thedition, Springer, New York, 2007.
2. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, First South Asian Edition 2005, Cambridge University Press.
3. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edition, Wiley, 2007.

Practical:

1. Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
2. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
3. Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
4. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
5. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
6. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi

7. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 17 (DSE-17): Molecular Spectroscopy and Structural Analysis

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Molecular Spectroscopy and Structural Analysis **(DSE-17)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To introduce the fundamental principles of spectroscopy, including the characterization of electromagnetic radiation and the Born-Oppenheimer approximation.
- To explore transition dipole moments and selection rules, with emphasis on symmetry ideas and time-dependent perturbation in spectroscopic processes.
- To analyze the principles and instrumentation of Raman spectroscopy and understand vibrational and rotational Raman spectra.
- To study the spectroscopic techniques for structural analysis i.e. AFM, SEM, and TEM.

Learning outcomes

By studying this course, the students will be able to:

- **U**nderstand the principles of electromagnetic radiation and fundamental spectroscopic concepts, including the Born-Oppenheimer approximation and time-dependent perturbation.
- Analyze Raman spectroscopy and deduce the structure of molecules using vibrational and rotational Raman spectra.
- Describe the Atomic spectra, the spin and orbital selection rules, spectra of complex atoms and basic principles of atomic photoelectron spectroscopy.
- Exhibit their understanding of theoretical basis of rotational, vibrational, raman and NMR spectroscopy.
- Have an insight into spectroscopic techniques for Structural Analysis i.e. SEM, TEM and AFM.

Unit 1: Basic Concepts of Spectroscopy and Atomic Spectra (8 Hours)

Spectroscopy and its importance in chemistry. Heisenberg Uncertainty Principal; Link between spectroscopy and quantum chemistry. Types of spectroscopy. Time dependent perturbation. Einstein coefficients. Integrated absorption coefficients. Transition dipole moments and general selection rules based on symmetry considerations.

Characterization of atomic states. Microstate and spin factoring methods. Hund's rules. Derivation of spin and orbital selection rules (based on recursion relations of Legendre polynomials. Spectra of complex atoms. Zeeman and Stark effects, Atomic photoelectron spectroscopy (Qualitative Discussion only).

Unit 2: Rotational, Vibrational and Raman Spectroscopy (14 Hours)

Rotational spectroscopy Determination of bond lengths and atomic mass. Effect of isotopic substitution. Non-rigid rotator. Classification of polyatomic molecules. Energy levels and spectra of symmetric top molecules and asymmetric top molecules.

Normal coordinate analysis of homonuclear and heteronuclear diatomicmolecules. Anharmonic oscillator; Morse potential. Overtones and hot-bands. Dissociation energies from vibrational data. Vibration-rotation spectra, P, Q and R branches. Breakdown of the Born-Oppenheimer approximation. Nuclear spin effect. Symmetry of normal coordinates.

Stokes and anti-Stokes lines. Polarizability ellipsoids. Rotational and vibrational Raman spectroscopy. Selection rules. Rule of Mutual Exclusion. Polarization of Raman lines.

Unit 3: NMR spectroscopy: (5 Hours)

Larmor precession. Mechanisms of spin-spin and spin-lattice relaxations and quantitative treatment of relaxation. Quantum mechanical treatment of the AB system. Selection rules and relative intensities of lines.

Unit 4: **Microscopic Techniques for Structural Analysis (3 Hours)**

Elementary idea of Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), and Atomic Force Microscope (AFM) for structural analysis.

Practicals: Credits: 02
(Laboratory periods:15 classes of 4 hours each)

1. Analyse UV-Vis absorption spectra of conjugated systems (e.g., β-carotene) and determine the HOMO-LUMO gap.
2. Study the effect of structure on the UV spectra of organic compounds.
3. Study the spectra of mesityl oxide/benzophenone in different solvents and classify the observed transitions in terms of $n\rightarrow\pi^*$ and $\pi\rightarrow\pi^*$ transitions. Discuss the shift in transitions relative to those in acetone.
4. Find the stoichiometry of the charge transfer (CT) complex formed between thiocyanate ions and iron (III) by Job's method of continuous variation.
5. Record the UV spectra of a weak acid (α-naphthol) at different pH and determine the dissociation constant in the ground state.

Hands-on/ Demonstration/ Instruction Mode: Demonstration/Discussion of working principle/Hands-on with substantial literature analysis/Laboratory exercise

6. Record and compare IR spectra of alcohols in pure form and diluted in non-polar solvents to understand the effect of hydrogen bonding on O-H stretching frequency.
7. Perform IR and Raman spectroscopy on symmetrical molecules (e.g., CS_2, CO_2) and analyze the mutual exclusion principle.

8. Calculate the force constant (k) of diatomic molecules (e.g., HCl, N_2) from IR spectra.
9. Create a calibration curve and use it to determine the concentration of a fluorophore in unknown samples.
10. Simulate and analyze rotational spectra of rigid rotor molecules.
11. Measure absorbance vs. time data to study the kinetics of fast photochemical reactions (using Time-Resolved Absorption Spectroscopy for Reaction Kinetics).
12. Resolve and assign vibrational fine structure in the UV-Vis spectrum of iodine vapor.

Essential/recommended readings

Theory:

1. Hollas. J. M., *Modern Spectroscopy* 4th Ed., John Wiley & Sons (2004).
2. Satyanarayana, D. N., *Handbook of Molecular Spectroscopy: From radio waves to gamma rays*, I.K. International Publishing House, New Delhi (2015).
3. Kakkar, R., *Atomic & Molecular Spectroscopy,* Cambridge University Press (2015).
4. Brand, J. C. D. & Speakman, J. C. *Molecular Structure: The Physical Approach* 2nd Ed., Edward Arnold: London (1975).
5. Chang, R. *Basic Principles of Spectroscopy* McGraw-Hill, New York, N.Y. (1970).
6. Moore, W. J. *Physical Chemistry* 4th Ed. Prentice-Hall (1972).
7. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 1st Edition, Mc Graw Hill Education.

Practical:

1. B. D. Khosla, V. C. Garg, A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy.
3. A. Findlay, B.P. Levitt, J.A. Kitchener, Experimental Physical Chemistry.
4. Donald A. McQuarrie and John D. Simon, Physical Chemistry: A Molecular Approach.
5. J. Michael Hollas, Modern Spectroscopy.
6. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis.
7. Jeanne L. McHale, Molecular Spectroscopy.
8. Donald L. Pavia, Gary M. Lampman, George S. Kriz, Introduction to Spectroscopy.
9. Gurdeep R. Chatwal and Sham K. Anand, Spectroscopy: Atomic and Molecular.
10. Peter Atkins and Ronald Friedman, Molecular Quantum Mechanics.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

Discipline Specific Courses Applicable Specifically for B.Sc. Life Sciences

DISCIPLINE SPECIFIC ELECTIVE COURSE – 18 LS (DSE-18 LS): Nanomedicine and Nanosensing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanomedicine and Nanosensing **(DSE-18 LS)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To discuss the various nanomaterials to be used as drug delivery systems.
- To develop an understanding of living system interaction of nanomaterials
- To enable learners to have an insight into the field of nanodiagnostics.
- To explain nature of nanomaterials as nanosensors.

Learning outcomes

By studying this course, the students will be able to:

- Demonstrate understanding of the concept of nanomaterial as efficient drug delivery systems.
- Evaluate Living System Interaction of Nanomaterials, thereby, exhibit foray into field of nanodiagnostics.
- Understand basic principle of gas sensing, chemosensing, biosensing, Optical, electrochemical, magnetic sensing using various nanoparticles.
- Perform hands-on laboratory exercise aimed at designing a variety of nanomaterials and their subsequent application in nanomedicine and nanosensing.

Unit 1: Nanomaterial and Drug Delivery - (8 Hours)

Nanomaterials of biological interest: Lipid-, polymer-(PLGA, PVP), inorganic-based (Gold, iron-oxide and silica) and hybrid nanomaterials. Nanomaterials as drug delivery systems. Encapsulation and release of drugs, photosensitizers (porphyrins), DNA, and other active agents i.e. coumarin dyes. Stimuli-responsive drug release.

Unit 2: Living System Interaction of Nanomaterials (7 Hours)

Interaction of nanomaterials with mammalian cells; Endocytosis, phagocytosis, pinocytosis, and other cell-entry mechanisms. Fate of nanoparticles inside cells. In vitro assays: cell viability, ROS determination, biochemical assays, etc.

Unit 3: Nanodiagnostics **(7 Hours)**

Nanodiagnostics: Basics of optical imaging, MRI, CT imaging, radioimaging. Nanomaterials (gold nanospheres and nanorods, dye-doped silica nanoparticles) for optical imaging, magnetic resonance imaging, CT imaging, radio-imaging, etc. Structural and Functional imaging. Image-guided drug delivery.

Unit 4: Nanosensing **(8 Hours)**

Basic principle of gas sensing, chemosensing, biosensing, Optical, electrochemical, magnetic sensing using various nanoparticles (gold nanospheres and nanorods, iron-oxide nanoparticles, nanographene and nanographene oxide). In vitro diagnostics from simple body fluids such as blood and urine. Microfluidic technology for low volume and high throughput sensing.

Practicals: **Credits: 02**

(Laboratory periods:15 classes of 4 hours each)

Hands-on/Demonstration/ Instruction Mode: Demonstration/ Discussion of working principle/ Hands-on with substantial literature analysis/ Laboratory exercise.

1. (i) Synthesis of nanoparticles: Gold nanospheres and nanorods, nanographene, iron-oxide nanoparticles.
   (ii) Characterization and differentiation of Gold nanospheres and nanorods using spectrophotometric analysis.
2. Preparation of PLGA nanoparticles.
3. Preparation of liposomes, solid-lipid nanoparticles (SLNs),
4. Synthesis of silica and organically modified silica (ormosil) nanoparticles,
5. Estimation of loading capacity of Drug/dye and release kinetics study in liposomes, PLGA nanoparticles, SLNs, ormosil nanoparticles, and ZIF-8 nanoscale frameworks (Any one system).
6. Comparative reaction kinetics study of dye-degradation (rhodamine-B) using Au/ Ag/ Au-Ag nanoparticles.
7. Colorimetric determination of trace amount of metal ions *(Iron or copper)* using gold nanospheres/nanorods.
8. LED-light-activated photothermal experiments using gold nanospheres/nanorods using temperature change measurements.
9. Determination of protein binding capacity of gold nanoparticles using NMR study.

Essential/recommended readings

Theory:

1. Prasad 1. P. N.. Introduction to Nanomedicine and Nanobioengineering. Wiley, 2012.
2. Webster. T. J. Nanomedicine Technologies and Application (2 nd Edition) ScienceDirect, 2023.
3. Jain. K. K. The Handbook of Nanomedicine. Springer, 2017
4. Kulkarni S. K., Nanotechnology: Principles and Practices, Springer Cham, 2014 (978-3-319-09171-6).
5. Singh K., Nanoparticle Therapeutics, Academic Press Elsevier, 2021 (978-0-12-820757-4).

6. Ratner B. D., Hoffman A. S., Schoen F. J., Lemons J. E., Biomaterials Science, Press Elsevier, 2013 (978-0-12-374626-9)
7. Nelson D. L., Cox M., Principles of Biochemistry, WH Freeman, 7th ed. 2017 (978-1319108243)
8. Alberts B., Johnson A., Lewis J., Raff M., Roberts K., Walter P., Molecular Biology of the Cell, 4th ed., Garland Science, 2002, 10: 0-8153-3218-1

Practical:

1. Prasad P. N.. Introduction to Nanomedicine and Nano-bioengineering. Wiley, 2012.
2. Webster. T. J. Nanomedicine Technologies and Application (2 nd Edition) Science Direct, 2023.
3. Jain. K. K. The Handbook of Nanomedicine. Springer, 2017
4. Kumar C., Hormes J., Leuschner C., Nanofabrication Towards Biomedical Applications, Wiley Vch,, 2005 (9783527311156)
5. Greco R. S., Prinz F. B., Smith R. L., Nanoscale Technology in Biological Systems, CRC Press, 2004 (9780849319402).
6. Perera Y. R., South T.M., Hughes A. C., Parkhurst A. N., Williams O.C., Davidson M. B., Wilks C. A., Misna D. A., Fitzkee N.C., Using NMR spectroscopy to measure protein binding capacity on gold nanoparticles, *J. Chem. Educ.* 2020, *97, 3, 820-824*.
7. Bentley A. K., Farhoud M, Ellis A. B., Lisensky G.C., Nickel A-Marie L, Crone W. C., Template Synthesis and Magnetic Manipulation of Nickel Nanowires, *J. Chem. Educ.* 2005, *82, 5, 765-768*.
8. Oliveira M. L., Pagung E., Lorenzini L., Neves T.R., Pereira J.R.P., Ferreira S. A. D., Freitas M. B. J.G. de, Moura P. R.G., Lelis M. F. F., Synthesis of Iron Oxide Nanoparticles and their Application in Photo-Fenton Process: An Undergraduate Experiment in Chemistry, *J. Chem. Educ.* 2025, *102, 1590-1597*.
9. How to Characterize 4−90nm Size Gold Nanospheres with Experimental and Simulated UV−Vis and a Single SEM Image, *J. Chem. Educ.* 2023, *100, 1589-1596*.
10. Nedrygailov I, Brien D. O., Monaghan S., Hurley P, Biswas S., Holmes J.D., Nanowood: A Unique Natural Nanomaterial That Can Be Obtained Using Household Chemicals, *J. Chem. Educ.* 2024, *101, 11, 4931-4936*.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SEMESTER VIII

Discipline Specific Courses (Common Pool) applicable for both B.Sc. Life Sciences and B.Sc. Physical Sciences

DISCIPLINE SPECIFIC ELECTIVE COURSE – 19 (DSE-19)
Fundamentals of Natural Products

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Fundamentals of Natural Products **(DSE-19)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

The primary objective of this course is to provide students with a comprehensive understanding of natural product chemistry, including its historical development, modern applications, classification, biosynthesis, and methods for isolation and purification.

Learning outcomes

By studying this course, the students will be able to:

- Understand the scope and significance of natural product chemistry in both historical and modern contexts, particularly its role in drug discovery.
- Analyze and classify major natural product groups-such as alkaloids, terpenoids, flavonoids, phenolics, peptides, glycosides, polyketides, steroids, and hormones-and understand their structures and functions.

Unit 1: Introduction and Classification of Natural Products: (11 Hours)

Definition and scope of natural product chemistry, historical significance and modern relevance, Primary vs secondary metabolites, Sources of natural products: terrestrial and marine origin, importance in drug discovery and development.

Alkaloids, Terpenoids, Flavonoids, Phenolics, Peptides and Proteins, Glycosides, Polyketides, Steroids and Hormones. Isoprene rule, mevalonate and non-mevalonate pathways, Shikimic acid pathway.

Unit 2: Isolation and Purification Techniques: (4 Hours)

Extraction methods (solvent extraction, Soxhlet, maceration, etc.), Chromatographic techniques (TLC, Column, HPLC, GC-MS), Crystallization and distillation techniques, Bioassay-guided fractionation.

Unit 3: Total Synthesis of Natural Products: **(10 Hours)**
Artemisinin (Antimalarial); Berberine (anti-inflammatory); Lysergic Acid Diethylamide (Psychedelic drug), and Vitamin B12.

Unit 4: Biosynthesis of Natural Products: **(5 Hours)**
Artemisinin, Berberine, and Lysergic Acid Diethylamide (LSD).

Practicals: **Credits: 02**
(Laboratory periods:15 classes of 4 hours each)

1. Isolation of natural products: Isolation of β-carotene from carrots.
2. Isolation of natural products: Isolation of limonene from lemon peel/orange peel.
3. Isolation of natural products: Isolation of caffeine from tea leaves.
4. Isolation of natural products: Isolation of piperene from black pepper.
5. Isolation of natural products: Isolation of eugenol from cloves.
6. Isolation of protein and carbohydrates from seeds –colour test.
7. Synthesis of 7-hydroxy-4-methylcoumarin
8. Synthesis of a simple dipeptide(gly-gly) by DCC coupling using N-protected amino acids.
9. Synthesis of simple amino acids

Essential/recommended readings
Theory:

1. Mann, J.; Davidson, R. S. & Hobbs, J. B., Natural Products: Their Chemistry and Biological Significance, Longman Scientific & Technical (1994)
2. Mann, J. Secondary Metabolites, Oxford University Press, Oxford, UK, (1980)
3. Hanson, J. R., Natural Products: The Secondary Metabolites, The Royal Society of Chemistry, Cambridge, UK (2003)
4. Chatwal, G., Organic Chemistry of Natural Products, Himalaya Publishing House (1994)

Practical:

1. Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
2. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
3. Furniss, B. S., Hannaford, A. J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
4. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
5. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
6. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
7. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 20 (DSE-20)
Fundamentals of Medicinal Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Fundamentals of Medicinal Chemistry **(DSE-20)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

This course aims to introduce students to the foundational concepts of medicinal chemistry, highlighting its historical development and the significance of natural products as drug sources. Additionally, the course examines the structure, synthesis, therapeutic use, and basic SAR of key drugs like Ibuprofen, Paracetamol, Aspirin, and Penicillin.

Learning outcomes

By studying this course, the students will be able to:

- Understand the development and role of medicinal chemistry, understand the stages of drug discovery, and evaluate drug screening and clinical processes.

- Interpret how stereochemical and physicochemical properties influence drug behavior and efficacy.

Unit 1: Introduction to Medicinal Chemistry and Drug discovery: (15 Hours)

History and development of medicinal Chemistry. Sources of drugs, including natural products with examples, Stages of drug discovery, Stereochemical aspects, Physicochemical properties: solubility, acid-base, partition coefficient.

Target identification and validation, Screening of drugs, High throughput screening (HTS), Random and Systematic screening. Structure activity relationship (SAR), Hit identification, and Lead optimization

Unit 2: Pharmacokinetics (ADME): (5 Hours)

Drug administration/absorption, drug distribution, drug metabolism - Phase 1 and Phase 2, drug excretion, Half-Life of drugs, and Clinical trials.

Unit 3: Representative Synthetic Drugs: (7 Hours)

Structure, Synthesis, and Therapeutic Value of Representative Drugs: Fluconazole (antifungal), Penicillin (antibiotic), Isoniazid (antibiotic), and Azidothymidine (AZT; anti-HIV).

Unit 4: Bioin-formatics: Use of computational tools for drug design. **(3 Hours)**

Practicals: **Credits: 02**

(Laboratory periods:15 classes of 4 hours each)

1. Isolation and estimation of aspirin from commercial tablets
2. Synthesis of paracetamol from *p*-aminophenol
3. Synthesis of benzotriazole/benzimidazole.
4. Synthesis of 5,5'-Diphenylhydantoin.
5. Synthesis of dihydropyridine (DHP)/dihydropyrimidine (DHPM).
6. Study of physicochemical properties of pharmaceutically active compounds using computational methods.
7. Synthesis of Benzocaine, a topical pain reliever.
8. Isolation of Caffeine from tea leaves using solvent extraction techniques.
9. Estimation of Vitamin C.

Essential/recommended readings

Theory:

1. Patrick, G. L. *Introduction to Medicinal Chemistry*, Oxford University Press (2001)
2. Lemke, T. L. & William, *D. A., Foye's Principles of Medicinal Chemistry*, 5th Ed., USA (2002)
3. Dunlap, N. K. & Huryn, D. M., *Medicinal Chemistry*, Garland Science, New York (2018)
4. Mark W. Holladay, Richard B. Silverman. *The Organic Chemistry of Drug Design and Drug Action,* 3rd Ed. Academic Press (2014)

Practical:

1. Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
2. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
3. Furniss, B. S., Hannaford, A. J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
4. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
5. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press
6. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
7. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 21 (DSE-21)
Computational Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Computational Chemistry **(DSE-21)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To introduce the fundamental concepts and theoretical background of computational chemistry.
- To develop an understanding of quantum mechanical, semi-empirical and molecular mechanical methods used in molecular modeling and molecular dynamics.
- To enable learners to perform geometry optimization, energy calculations, and vibrational analysis using computational tools.
- To teach the interpretation of computational results in the context of chemical structure, and reactivity.
- To expose students to various software packages commonly used in computational chemistry
- To provide hands-on experience with setting up, running, and analyzing computational chemistry simulations.

Learning outcomes

By studying this course, the students will be able to:

- Demonstrate a solid understanding of key computational methods such as ab initio, semi-empirical, and molecular mechanical methods.
- Apply computational tools to predict and analyze molecular properties, geometries, and reaction mechanisms.
- Perform and interpret quantum chemical and molecular simulation calculations using standard software packages.
- Evaluate the accuracy and limitations of various computational approaches in relation to experimental data.
- Design and conduct computational experiments to solve problems in chemical research and development.

Unit 1: Fundamentals of Computational Chemistry **(6 Hours)**

Conceptual background of computational chemistry and molecular modeling, Z-matrix of simple molecules, Born-Oppenheimer approximation and Potential Energy Surfaces (minima and maxima), harmonic frequency calculations and intrinsic reaction coordinate. Charge analysis (Milliken. NBO, etc.). Cost and efficiency.

Unit 2: Molecular Mechanics and Molecular Dynamics (12 Hours)
Molecular Mechanics: Force Fields, Non-bonded interactions (van der Waals and electrostatic, hydrogen bonding), Parameterization. The applications of MM, the disadvantages, and the different variants of MM (MM1, MM2, MM3, MM4, AMBER, OPLS, etc).; Molecular Dynamics: Ensembles (microcanonical, canonical, isothermal – isobaric), Concept of periodic box, Ergodic hypothesis. Leapfrog and Verlet Algorithms (qualitative treatment), Typical MD simulations.

Unit 3: Semi-empirical Methods (3 Hours)
Brief idea of semi-empirical method; CNDO, INDO, MNDO, AM1, PM3.

Unit 4: Quantum Mechanical Methods (9 Hours)
Brief idea of quantum mechanical methods; HF, MP2, DFT, CC, and CI (conceptual and qualitative discussion only)
Conceptual ideas of Basis sets (STOs and GTOs), diffuse and polarization functions, Basis set superposition error (BSSE), Effective Core Potentials (ECP), and HOMO-LUMO. Awareness of available computational chemistry software.

Practicals: Credits: 02

(Laboratory periods:15 classes of 4 hours each)

1. Find the Z-matrix of diatomic (i.e., H_2, HCl), triatomic (i.e., H_2O, HNO, HCN) and tetratomic (i.e., H_2CO, HNO_2, BH_3, cis- and trans-diazene) molecules, etc.
2. Determine the optimized geometry of HF, HCl, and HBr molecules and compare the optimized geometrical parameters, formal charges, vibrational frequencies, and dipole moments using AM1, HF, and DFT (using at least three different basis sets).
3. Determine the optimized geometry of HF, HCl, and HBr molecules and compare the optimized geometrical parameters, formal charges, vibrational frequencies, and dipole moments by DFT method at least three different basis sets using any suitable method.
4. Determine the optimized geometry of H_2O, H_2S, and H_2Se molecules and compare the optimized geometrical parameters, formal charges, vibrational frequencies, and dipole moments by HF, DFT and MP2 methods using at least three different basis sets.
5. Calculate and compare the C-C, C=C and C≡C bond dissociation energies of ethane, ethylene, and acetylene molecules, respectively, using any suitable method/basis set.
6. Calculate and compare the bond dissociation energies of HF, HCl, and HBr molecules using any suitable method/basis set.
7. Generate the potential energy surface diagram for the rotational profile of the ethane molecule around the C–C bond.
8. Generate the potential energy surface diagram for the rotational profile of the butane molecule around the C_2–C_3 bond
9. Determination of Frontier Molecular orbitals of H_2, CO, HF, H_2O, H_2CO and benzene molecules using any suitable method/basis set.

10. Determine the activation energy for the isomerization of cis-diazene to trans-diazene by computing the equilibrium geometries and the transition state structure using any suitable method/basis set.
11. Calculate the intrinsic reaction coordinate (IRC) for cis-diazene to trans-diazene transformation using any suitable method/basis set.
12. Using optimized geometries, calculate the reaction enthalpy at 298 K for the following industrially important reactions (Haber-Bosch process) based on the enthalpies of the involved species: $CH_4 + H_2O \rightarrow CO + 3H_2$
13. Calculate formaldehyde/benzene's electronic UV/Visible absorption spectrum.
14. Based on the conceptual DFT, calculate the ionization potential (IP), electron affinity (EA), electronegativity, and electron chemical potential of a given set of molecules.
15. Study the mechanism of *SN_2* reaction between Cl^- and CH_3Br involving a Walden inversion computationally.
16. Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.
17. Predict the aromaticity of thiophene with respect to benzene by comparing their enthalpies of hydrogenation.
18. Arrange 1-hexene, 2-methyl-2-pentene, (E)-3-methyl-2-pentene, (Z)-3-methyl-2-pentene, and 2,3-dimethyl-2-butene in order of increasing stability.
19. Compare the basicity of the nitrogen atoms in ammonia, methylamine, dimethylamine, and trimethylamine by comparison of their charges and ESP maps.
20. Compare the HXH bond angles for the second-row hydrides (BeH_2, CH_4, NH_3, H_2O) and compare with the results from qualitative MO theory (here, X = Be, C, N and O).
21. (a) Compare the shapes of the molecules: 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2-propanol. Note the dipole moment of each molecule. (b) Show how the shapes affect the trend in boiling points: (118 ºC, 100 ºC, 108 ºC, 82 ºC, respectively).

Note: Minimum 12 exercise to be performed**.** Any other practical may also be performed as directed by the instructor.

NB: *Some suggested free open-source software tools include:*
(a) *For visualization and basic tasks: Avogadro, Jmol, RasMol, Molden, IQmol, PyMOL, VMD, MacMolPlt, ArgusLab, ChemCraft (for 150 days) or any other software may be used.*

(b) *For calculations and simulations: Avogadro, ArgusLab, Dalton, Ergo, GAMESS, ORCA, NW Chem, MPQC, Psi4, Quantum ESPRESSO, ABINIT, CP2K, TINKER or any other available software may be used.*

References:

1. C. J. Cramer, *Essentials of Computational Chemistry-Theories and Models*, John Wiley and Sons Ltd., 2nd Ed., 2004.
2. F. Jensen, *Introduction to Computational Chemistry*, John Wiley and Sons Ltd., 3rd Ed., 2017.

3. Free and open source software for computational chemistry education, S. Lehtola and A. J. Karttune, *Comput Mol Sci*. (2022); 12, e1610. doi: 10.1002/wcms.1610
4. Online manual of
   a) *Gaussian 16,* www.gaussian.com
   b) *GAMESS,* www.msg.ameslab.gov/gamess
   c) *Q-Chem, https://manual.q-chem.com/latest/*
5. J. B. Foresman and Æ Frisch, *Exploring Chemistry with Electronic Structure Methods*, 3rd ed., Gaussian, Inc.: Wallingford, CT, 2015.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 22 (DSE-22): Machine Learning and Artificial Intelligence in Chemistry

***For syllabus content of Discipline Specific Elective-22: (DSE-22)** "Machine Learning and Artificial Intelligence in Chemistry refer to the pool of DSE courses in 4^{th} year syllabus of **B.Sc. (H) Chemistry**.

Discipline Specific Courses Applicable Specifically for B.Sc. Life Sciences

DISCIPLINE SPECIFIC ELECTIVE COURSE – 23 LS (DSE-23 LS)
Bioelectrochemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Bioelectro-chemistry **(DSE-23 LS)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives
The objectives of this course are as follows:
- To provide a conceptual understanding of the various types of electrodes and the electrochemical processes.
- To equip the students with conceptual understanding of the electrical double layer and Equivalent circuit models of EDL; Gouy-Chapman Model etc.
- To help build an insight into Interfacial Electron Transfer in Biological Systems.
- To provide an understanding of the concept of bio-electrocatalysis and electrochemical communication in biological organisms.

Learning outcomes
By studying this course, the students will be able to:
- Differentiate between different electro systems and account for the electrochemical processes at the electrodes.
- Demonstrate their understanding of the electrical double layer, membrane potential and the concept of interfacial electron transfer in biological systems.
- Exhibit their understanding of Chemical signalling, electrical signalling. Electrochemical mechanisms of the nervous system
- Develop an insight into Bioelectrocatalysis Using Enzymes electrodes.

Unit 1: Electrode and Electrochemical Processes (8 Hours)
Qualitative conceptual description of working and Counter Electrodes, Reference Electrodes: standard hydrogen electrode (SHE), or normal hydrogen electrode (NHE), saturated calomel electrode (SCE), silver-silver chloride electrode, potential of zero charge, open-circuit potential of the cell, overpotentials.
Faradaic and Nonfaradaic Processes: Ideally polarizable electrode, Capacitance and Charge of an Electrode, supporting electrolyte, Nernst equation, Nernst potential and biological systems.

Description of the Electrical Double Layer: Stern Potential, Zeta potential. Membrane potentials, simplistic theories of membrane potentials, electrical conduction in biological organisms: electronics and protonics.

Unit 2: Electrical Double Layer (8 Hours)

Description of the Electrical Double Layer: inner and outer compact layer Helmholtz, Stern layer, Diffuse Layer, specifically and non-specifically adsorbed ions, Potential profile across the double-layer region in the absence of specific adsorption of ions, Equivalent circuit models of EDL, Gouy-Chapman Model (Qualitative discussion only)

Brief qualitative discussion of basic principle and application of electrophoeresis, Electrochemical impedance spectroscopy and cyclic voltammetry techniques.

Unit 3: Interfacial Electron Transfer in Biological Systems (6 Hours)

Electrode kinetics, Butler-Volmer equation, adsorption of proteins onto metals from solution, electron transfer from biomaterials to simple redox ions in solution, theoretical aspects of electron transfer from solid proteins to ions in solution.

Unit 4: Electrochemical Communication and Bio-Electrocatalysis (8 Hours)

Chemical signalling, electrical signalling. Electrochemical mechanisms of the nervous system, theory of the spike potential. Monitoring neurotransmitters in the intact brain and other single-cell studies.

Bio-Electrocatalysis, electrodes carrying enzymes, electrochemical enzyme-catalyzed oxidation of styrene.

Practicals: Credits: 02

(Laboratory periods:15 classes of 4 hours each)

1. Conductometric Titration of a Charge Transfer System, the formation of charge transfer complex between an electron donor and acceptor is studied and the stoichiometry of the complex is determined by following the variation of conductance of the solution with concentration of the donor and acceptor.
2. Effect of ionic strength on reaction rate (persulfate-iodine reaction).
3. Potentiometric determination of solubility and solubility product of AgCl(s) in water.
4. Potentiometric determination of mean ionic activity coefficient of HCl at different concentrations.
5. Potentiometric titration of Phosphoric acid vs NaOH.
6. Determination of dissociation constant of acetic acid from its potentiometric titration curve.

Hands-on/Demonstration/ Instruction Mode: Demonstration/ Discussion of working principle/ Hands-on with substantial literature analysis/ Laboratory exercise.

7. To measure the Vitamin C content of commercial Orange Juice using Pencil Lead as a working electrode in cyclic voltammetry.
8. Synthesis and Cyclic voltammetry study of Nano-wood, prepared using household Chemicals.
9. Record cyclic voltammogram for a reversible heterogeneous electron transfer system with varying scan rates,
   (i) Determine anodic and cathodic peak current ratio.

(ii) Determine anodic and cathodic peak potential difference.
(iii) Plot peak current vs square root of scan rates.
(Use aqueous solution of 10 mM $K_4Fe(CN)_6$ + $K_3Fe(CN)_6$ + 1.5 M $NaNO_3$)

10. Record cyclic voltammogram for a quasi-reversible heterogeneous electron transfer system with varying scan rates,
    (i) Determine anodic and cathodic peak current ratio.
    (ii) Determine anodic and cathodic peak potential difference.
    (iii) Plot peak current vs square root of scan rates.
    (Use aqueous solution of 10mM $Fe(NH_4)_2 (SO_4)_2$ + $Fe(NH_4)(SO_4)_2$ + 1 M $HClO_4$)
11. Record the CV of aqueous solution of sulphuric acid (0.5 M) at Pt electrode as working electrode and counter electrode.
    (i) Interpret and explain various peaks and region of the CV and their significance.
    Determine the area and roughness factor of the electrode by Pt oxide region.

Essential/recommended readings
Theory:

1. Bockris, J. O' M. & Reddy, A. K. N. Modern Electrochemistry 2A: Fundamentals of Electrodics 2nd Ed., Springer (2001).
2. Bockris, J. O' M. & Reddy, A. K. N. Modern Electrochemistry 2B: Electrodics in Chemistry, Engineering, Biology and Environmental Science 2nd Ed., Springer (2001).
3. Bard, A. J. Faulkner, L. R. Electrochemical Methods: Fundamentals and Applications, 2nd Ed., John Wiley & Sons: New York, 2002.
4. Oldham, K. B., Myland, J. C. and Bond, A. M. Electrochemical Science and Technology: Fundamental and Applications, John Wiley & Sons, Ltd. (2012).
5. Brett, C. M. A. & Brett, A. M. O. Electrochemistry, Oxford University Press (1993).
6. Koryta, J., Dvorak, J. & Kavan, L. Principles of Electrochemistry John Wiley & Sons: NY (1993).
7. Bagotsky, V.S., Fundamentals of Electrochemistry 2nd Ed. Wiley – Interscience, (2006)
8. Hamann, Carl H., Hamneff, Andrew & Vielstich, Wolf., Electrochemistry, 2nd Ed. (2007)

Practical:

1. Khosla B. D., Garg V. C., Gulati A., Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. Holze R., (2019) Experimental Electrochemistry: A laboratory Textbook, Wiley-VCH.
3. Brabec V., Walz D., Milazzo G., Experimental techniques in Bioelectrochemistry, Springer.
4. Bartlett P. N., Bioelectrochemistry: Fundamentals, Experimental Techniques and Applications, John Wiley & Sons Inc.
5. Elgrishi, N.; Rountree, K. J.; McCarthy, B. D.; Rountree, E. S.; Eisenhart, T. T.; Dempsey, J. L. A Practical Beginner's Guide to Cyclic Voltammetry, *J. Chem. Educ.* **2018**, *95*, *2*, 197–206.
6. Field, R. J.; Schneider, F. W. Oscillating Chemical Reactions and Nonlinear Dynamics, *J. Chem. Educ.* **1989**, *66*, *3*, 195–204.
7. King D, Friend J., Kariuki J., *Measuring Vitamin C Content of Commercial Orange Juice Using a Pencil Lead Electrode, J. Chem. Educ.* **2010**, *87*, *5*, 507–509.
8. Lima D, Singh V, Bulleeraz K, Lussier J. A., Kuss S., Electrifying Fruit Juice: Integrating Applied Electroanalytical Chemistry into the Undergraduate Curriculum, *J. Chem. Educ.* **2024**, *101, 7, 2938-2946.*

Assessment Methods: **All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.**

DISCIPLINE SPECIFIC ELECTIVE COURSE – 24 LS (DSE-24 LS)

Nanomaterials and their Biological Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanomaterials and their Biological Applications **(DSE-24 LS)**	**04**	**02**	**--**	**02**	Class12th with Physics, Chemistry Biology	**--**

Course Objectives

The objectives of this course are as follows:

- To study about fundamentals and applications of Advanced Inorganic materials.
- To understand the mechanism of synthesis of hydrogels, composites, mesoporous materials.
- To understand the fabrication of materials for their notable applications in living systems.
- To know how these materials are making life easier in this era and are great sources of industrial growth and technological changes.

Learning outcomes

By studying this course, the students will be able to:

- Understand various materials, their synthesis and properties.
- Explain the mechanism of growth of self-assembled nanostructures.
- Explain the importance of hydrogels composites, mesoporous materials and their applications.
- Understand the usage of materials in various fields ranging from modern life to Human health, and environment.
- Develop skills in the scientific method of planning, developing, conducting, reviewing and reporting experiments.

Unit1: Nanomaterials **(8 Hours)**

Overview of nanostructures and nanomaterials, classification, preparation and optical properties of gold and silver metallic nanoparticles, concept of surface plasmon resonance, carbon nanotubes, inorganic nanowires, Bioinorganic nanomaterials, DNA and its nanomaterials, natural and artificial nanomaterials, self-assembled nanostructures, control of nanoarchitecture, one dimensional control.

Unit 2: Composite materials **(7 Hours)**

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, bio-nanocomposites, environmental effects on composites, applications of composites.

Unit 3: Hydrogels: **(10 Hours)**
Introduction, natural, synthetic, and hybrid hydrogels, Properties of hydrogels, different methods of synthesis, notable hydrogel systems such as alginate-based, PEGDA, and PVA hydrogels, Applications of hydrogels such as environmental remediation, Food packaging, sensor, and biomedical.

Unit 4: Nanomaterials for Biomedical Applications **(5 Hours)**
Inorganic nanomaterials: silica, carbon based, metallic, oxides.
Biomedical applications: Quantum dots, gold nanoparticles, and magnetic nanoparticles for imaging, biosensing, therapeutics and diagnostics. Polymeric nanoparticles, dendrimers, and carbon nanotubes applied to drug delivery systems. Nanomaterials such as nanofibers, and nanocomposite materials as scaffold materials for tissue engineering and regeneration. Nanotoxicology.

Practical: **Credits: 02**

1. Synthesis of hydrogels and study of swelling behavior.
2. Preparation of zeolite A and removal of Mg and Ca ions from water samples quantitatively using zeolite.
3. Synthesis of ZnO, NiO nanoparticles by green approach methods and characterization using UV-visible spectrophotometer.
4. Synthesis of Cu doped ZnO nanoparticles.
5. Synthesis of CuS, MnS and CdS nanoparticles and their characterization using UV- visible spectrophotometer.
6. Synthesis of gold and silver nanoparticles and study of their optical properties as a function of size.

Recommended Texts:
Theory:

1. West, A. R. (2014), Solid State Chemistry and Its Application, Wiley.
2. Smart, L. E.; Moore, E. A., (2012), Solid State Chemistry: An Introduction CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J. (1997), New Direction in Solid State Chemistry, Cambridge University Press.
4. Xu, C.; Zang Y. S.; Begin S.; Thanh N. T. K.; Nanoscale, 2022,14, 7441-7443.
5. Poole Jr.; Charles P.; Owens, Frank J. (2003), Introduction to Nanotechnology, John Wiley and Sons.

Practical:

1. Cheng, K.H.; Jacobson, A.J.; Whittingham, M.S. (1981), Hexagonal Tungsten Trioxide and Its Intercalation Chemistry, Solid State Ionics, 5, 1981, 355-358.
2. Ghorbani H.R.; Mehr, F.P; Pazoki, H; Rahmani, B.M.; Synthesis of ZnO Nanoparticles by Precipitation Method, Orient J Chem 2015, 31(2).
3. A.K. Sharma, R. Sharma, B. Pani, A. Sarkar, M. Tripathi, Engineering the Future with Hydrogels: Advancements in Energy Storage Devices and Biomedical Technologies. New Journal of Chemistry, RSC, 2024, 48, 10347-10369.
4. Xu, C.; Zang Y. S.; Begin S.; Thanh N. T. K.; Nanoscale, 2022,14, 7441-7443.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

List of Instruments/Software required for Implementation of Fourth year Course of Study for each College

1. UV- Vis Spectrophotometer
2. Table top IR Spectrophotometer
3. ChemDraw, GaussView6/ GaussView5 and Gaussian 16/Gaussian 09 Software
4. Access to p-XRD NMR Spectrophotometer in Department of Chemistry/USIC
5. Rota Evaporator
6. Sonicator
7. Cyclic Voltammeter/ Potentiostate-Galvanostate

Annexure-15

Frameworks for VII and VIII semesters

B.Sc. (H) Applied Life Sciences with Agrochemicals and Pest Management

Semester	DSC Credits 4	DSE Credits 4
VII	DSC 07 (3T+1P)	DSE I (2T + 2P) DSE II (2T + 2P) DSE III (2T + 2P)
VIII	DSC 08 (3T+1P)	DSE IV (2T + 2P) DSE V (2T + 2P) DSE VI (2T + 2P)

VII

- ➢**DSC 07:** Agrochemicals for Insect and Mite Control
- ➢**DSE I**: Research Methodology in Agrochemistry
- ➢**DSE II**: Physical Principles in Agrochemicals
- ➢**DSE III**: Analytical Techniques in Pesticide Analysis

VIII

- ✓**DSC 08**: Agrochemical for Fungi, Nematodes, and Weeds
- ✓**DSE IV**: Environmental health and Agrochemicals
- ✓**DSE V** Introduction to Natural Pesticides: Biopesticides and Plant Toxins
- ✓**DSE VI:** Pesticide Formulation and Application Equipment

SEMESTER –VII

BSc. (Hons)Applied Life Sciences with Agrochemicals and Pest Management

Swami Shraddhanand College

DISCIPLINE SPECIFIC CORE COURSE – 01

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Agrochemicals for Insect and Mite Control: DSC 07	**4**	**3**	**0**	**1**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- to familiarize students to different types of classification of pesticides.
- to familiarize with factors that make the organic compound to be considered as pesticide.
- Develop a solid knowledge base regarding the chemistry, classification, and synthesis of agrochemicals—including insecticides and acaricides (pesticides used against mites).
- This entails learning about key chemical classes (such as organophosphates, pyrethroids, carbamates) and their modes of action and effective chemical control strategies

Learning outcomes

The Learning Outcomes of this course are as follows:

- To analyze important aspects attributing pesticidal activity to organic molecules.
- To explain the strategies involved in synthesis of different pesticides.
- To handle pesticides safely in view of human health and environment.
- To help the students to gain an in-depth understanding of both the theoretical and practical aspects of using agrochemicals for pest management

SYLLABUS OF DSC- 07

THEORY COMPONENT-

UNIT 1: **(17 Hours)**

A Structure, properties, uses, structure-activity relationship (QSAR) and toxicity with reference to selective examples each from class of selected examples of pesticides: Discussion on stereochemical aspects of pesticides insecticides, where ever required.

a) Organochlorines
b) Organophosphorus
c) Carbamates

B Structure, uses and toxicity examples each from:Pyrethrins,Pyrethroidsand Neonicotinoids. Discussion on stereochemical aspects of pesticides insecticides, where ever required.

a) Pyrethrins
b) Synthetic Pyrethroids
c) Neonicotinoids pesticides

UNIT 2:(10Hours)

Introduction to Insecticide synergists: Concept, Significance, andimportance,role in resistance management,mode of action,Common insecticide synergists-piperonylbutoxide and MGK-264 (n-octylbicycloheptanedicarboximide), Synergists Work Efficacy, Resistance Management, Reduced Insecticide Use

UNIT3: **(10 Hours)**

Introduction to Synthetic IGRs:Synthetic IGRs- Concept, Significance, andimportance,
Use of Synthetic IGRs- Mimicking Hormones, Disrupting Chitin Synthesis, targeting Specific Life Stages,
Advantages of Synthetic IGRs - Reduced Environmental Impact, Reduced Resistance Development, Compatibility with Integrated Pest Management (IPM),
Examples of Synthetic IGRs: Methoprene, Diflubenzuron, teflubenzuronChlorfluazuron ,Fenoxycarb

UNIT4: **(8 Hours)**

Fumigants and other chemicals for post-harvest storage of agricultural commodities

PRACTICAL COMPONENT (30Hours)

Synthesis of pesticides /analogues/intermediates

1. Preparation of carbamate derivative from phenylisocynate and alcohol/phenol.
2. Preparation of DDT from chlorobenzene and chloral
3. Preparation of other chlorinated hydrocarbons DDE, and Methoxychlor
4. Preparation of organophosphorus Insecticide-Part A –phosphorodichloridite, and Part B -phosphonate
5. Preparation and characterization of oxime ether, Preparation of DDVP.
6. Preparation of acyl phenyl hydrazine
7. Preparation ofof 3,5-dimethylpyrazole
8. Preparation of mosquito repellent Diethyl phthalate in two steps:

   Step-1: Preparation of phthalic anhydride

   Step-2: preparation of Diethyl phthalate
9. Writing the assigned an in-depth analysis of at least three insecticides to be allotted by instructor fromorganochlorines, organophosphorus, carbamates, pyrethroids, and neonicotinoids. It must cover the detailed aspects of: Chemical Structure, Uses, Mode of Action, Toxicity and GHS labelling, Human Health Implications

ESSENTIAL/RECOMMENDED READINGS

1. G.T. (1976). *Chlorinated Insecticides* (Vols. I–II). CRC Press.
2. Buchel, K. H. (Ed.). (1992). *Chemistry of Pesticides*. John Wiley & Sons.
3. Cremlyn, R. J. (1990). *Pesticides: Preparation and Mode of Action*. Wiley.
4. Eto, M. (1979). *Organophosphorus Pesticides: Organic and Biological Chemistry*. CRC Press. *(Note: Corrected to insert a space between "Biological" and "Chemistry".)*
5. Kuhr, R. J., &Dorough, H. W. (1979). *Carbamate Insecticide Chemistry and Biochemistry*. CRC Press.
6. Leahey, J. P. (1985). *The Pyrethroid Insecticides*. Taylor & Francis.
7. Metlosky, G., Nadasy, M., &Andriska, V. (1988). *Pesticide Chemistry*. Elsevier.
8. Perry, U. K., Yamamoto, A. S., Ishaaya, I., & Perry, R. (1998). *Insecticides in Agriculture and Environment: Retrospects and Prospects*. Narosa.

KEYWORDS: QSAR, Stereochemical activity of Pesticides, Insecticide synergists, Synthetic synergists, Fumigants, Pesticide activity

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 01

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology inAgrochemistry	4	2	0	2	-	NIL

Course objectives

The Learning Objectives of this course are as follows:

- Understand Fundamental Concepts of research.
- Develop researchable questions and hypotheses related to pesticide application, efficacy, environmental impact, or health effects.
- Design Appropriate Research Methodologies and Distinguish between qualitative, quantitative, and mixed-method approaches in pesticide research.
- Use statistical tools to analyze pesticide research data. Address Ethical and Regulatory Considerations Describe relevant national and international pesticide regulations.
- Learning computational toxicology
- Develop Scientific Communication Skills. Write research proposals, reports, and scientific papers on pesticide-related topics.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Recall and identify key concepts and terminology related to research methodology.
- Analyze the strengths and weaknesses of different research methodologies in relation to specific research contexts or objectives.
- Apply the principles of a specific research methodology to design a research study or experiment.
- Computer in pesticide development.

SYLLABUS OF DSE- 01

THEORY COMPONENT-

UNIT 1: **(8Hours)**

Introduction of Research and Writing scientific report:
Meaning and objectives of research, criteria of good research, research methods vs research methodology, selection of research problem, literature review, types of hypotheses. Maintaining a laboratory record; On-line literature searching, Database, Sci-finder, Scopus, Citation Index, Impact Factor.

Planning, preparation, draft, revision and refining; writing project proposal to funding agency, Paper writing for Journals, Conference presentation, preparation of effective slides and presentation. Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism, Acknowledgement,Fellowships/Research Grants, Introduction to guidelines, Insecticides Act 1968 and Insecticides rules 1971

UNIT 2: **(8Hours)**

Computational tools used in chemical structure designing:
AutoDock, PyMOL, or ChemSketch,Marvin (Chem Axon), Determination of some selected physiochemical properties

UNIT 3: (10Hours)

Computational toxicology

A. Introduction to Toxicity prediction and hazard identification

Applicability domain (AD) of a QSAR mode, brief discussion on the models available for predicting toxicological endpoints, Physicochemical properties associated with toxicity, QSAR approaches and the definition of structural similarity a key aspect of silico prediction.

B. Software and expert systems in relation to the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) initiative and Organization for Economic Co-operation and Development (OECD) principles.

C. Computational models for toxicology,their Limitations of chemical similarity and Read-across for regulatory purposes.

D. Freely available Software for Toxicity prediction:

OECD QSAR Toolbox, EPA's Toxicity Estimation Software Tool (TEST), OPERA, VEGA, ProTox 3.0,SwissADME (Several other available software as per requirement may be used)

UNIT 4: (4 Hours)

Data exploration for the pesticide molecules:
Manually curated database sites for pesticides like ChEMBL, ChEBI, Agrochemical Database @ USDA, chemspider, BRENDA (enzyme data and metabolic information), UniProt (Enzyme database) PubChem etc. to be introduced.

PRACTICAL COMPONENT (60Hours)

For review and data analysis to be carried out for the given pesticides

1 **Utilization of Academic Search Engines and Databases.** Practice using platforms like Google Scholar, Scopus, and PubMed to locate and retrieve relevant research and review articles.

2 Conduct systematic reviews. Choose a topic (e.g., pesticide resistance in insects). Use online databases to find 5–10 relevant papers. Analyze them for research gaps, methods used, and key findings

3 Practice data entry and statistical analysis. Provide sample data (e.g., pesticide residue levels in water). Clean and organize data in Excel or R. Perform correlation or regression analysis. Interpret results.

4 Collection of data, interpretation, and presentation of data through writing short research or review papers

5 Develop skills to write concise and informative titles and abstracts for research manuscripts.

6 Use reference management tools (Zotero, Mendeley, EndNote) to format citations and bibliographies according to various journal styles.

7 Learn how to check for plagiarism using software tools (Turnitin, Grammarly, etc.) and maintain academic integrity.

8 Explore the basics of computational tools used in pesticide design (such as AutoDock, PyMOL, or ChemSketch).

9. Writing the assigned an in-depth analysis ofat least three pesticides to be allotted by instructor for their computational study for physicochemical data and toxicity prediction.

ESSENTIAL/RECOMMENDED READINGS

1. G.R.Chatwal, Instrumental method of chemical analysis.
2. A text of inorganic quantitative analysis by Shree Ramulu.
3. Instrumental methods of chemicals analysis by Willard, Meritt
4. Rastogi S.C. Mendecutta, N.Bioinformatics Methods and application
5. Sharma B.K. Instrumental Methods of chemical analysis
6. Chopra &Kanvar, Analytical agriculture chemistry
7. Robert Brown, Introduction to instrumental Analysis
8. Peter Atkins, Physical chemistry
9. Sivasankari, Bioseparation Principles and Techniques.
10. Practical Research Methods, Catherine Dawson, UBS Publishers Distribution, New Delhi 2002.
11. Research Methodology – Methods and Techniques, C. R. Kothari, Wiley Easter Ltd, New Delhi 1985.
12. Research Methodology – A Step by step Guide for Beginners 2 ndedn. Kumar Ranjit, Pearson Education, Singapore, 2005.
13. Introduction to Research and Research Methodology M. S. Sridhar.
14. The Information Specialist's Guide to Searching & Researching on the Internate& the World Wide Web by Ernest Ackermann, Karen Hartman, Fitrzroy Dearborn Publishers, London.
15. Learning to Use the World Wide Web, Ernest Ackermann, BPB Publications development and formulation development. Use of computer-based equipment for pesticide analysis.

KEYWORDS: Research methodology, Citation Index, Computational tools, QSAR approaches, Silico prediction, REACH, OECD, Computational models for toxicology, Toxicological endpoints, Agrochemical Database, Plagiarism

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE – 02

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Physical Principles in Agrochemicals	4	2	0	2	-	NIL

Course objectives

The Learning Objectives of this course are as follows:

- explain the laws of thermodynamics and their applications in agrochemical formulation and stability.
- Compute and interpret enthalpy, entropy, and Gibbs free energy changes in agrochemical reactions.
- Principles of catalysis and enzyme kinetics, particularly in the context of bio-pesticide action.
- Role of surfactants and micelles in pesticide formulations and critical micelle concentration (CMC)**.**
- Analyze how pKa and pH affect the ionization and solubility of pesticides in different environmental conditions.
- Correlate lipophilicity with pesticide bioavailability, uptake, and systemic activity in target organisms

Learning outcomes

The Learning Outcomes of this course are as follows:

- Define key physicochemical properties of pesticides (e.g., solubility, volatility, vapor pressure, partition coefficient, and degradation rates).
- Describe the fundamental principles of enzyme kinetics

- Define photochemical transformation and its relevance in the environmental fate of pesticides.
- Explain the mechanisms of direct and indirect photolysis of pesticides under natural and artificial light sources

SYLLABUS OF DSE- 02

THEORY COMPONENT-

UNIT 1: (7Hours)

Physicochemical Properties of Pesticides: Physicochemical properties (solubility, octanol-water partition coefficient, vapor pressure, soil adsorption coefficient, emulsion stability, half-life, shelf-life etc.) and their testing, Formulation-toxicant interactions.Distribution coefficient of pesticide-its mobility**,** persistence**,** and potential to contaminate environment. Significance ofstudying the physiochemical properties.

UNIT 2: (7Hours)

Photochemical transformation of pesticides:Introduction to photochemistry, direct and indirect photolysis, photosensitizers, quenchers, light filters, quantum yield. Photo transformation pesticides and their significance. An overview of broken-down Pesticide and health risk of altered transformed products photochemically.

UNIT 3: (10 Hours)

Enzyme Kinetics and Application in Agrochemical Degradation: Factors affecting the enzyme activity- Concentration, pH and temperature. Kinetics of a single-substrate enzyme catalysed reaction, Michealis-Menten Equation, Km, Vmax, L.B Plot, Turnover number, Kcat. Enzyme specificity. Active site, Principles of activation energy, transition state. Interaction between enzyme and substrate- Lock and Key Theory. Kinetics of Enzyme Inhibition- irreversible and reversible, types of reversible inhibitions- competitive and non-competitive. Feedback inhibition.

UNIT 4: (6Hours)

Surface and Colloid Chemistry in Agrochemicals: Critical micelle concentration (CMC), Emulsions, suspensions, and colloidal stability. Adsorption isotherms (Langmuir and Freundlich): application in soil-pesticide interaction. Wettability, contact angle, and spreadability on leaf surfaces.

PRACTICAL COMPONENT (60Hours)

1. To measure the solubility of a pesticide in water at room temperature.
2. To evaluate the lipophilicity of a pesticide by calculating log P using 1-Octanol/Water System.
3. To determine the dissociation constant (pKa) of an agrochemical using UV-Visible Spectroscopy.
4. To study how solubility varies with pH due to ionization of pesticide.
5. Determination of surface tension and contact angle of formulations.
6. Study of adsorption of pesticide on soil using isotherms.
7. Kinetics of pesticide degradation under various pH conditions.
8. To determine the distribution coefficient of a pesticide by studying its adsorption onto soil from an aqueous solution.
9. Writing the assigned an in-depth analysis of at least three pesticides to be allotted by instructor for evaluation of Physical principles by surveying the data from literature.

ESSENTIAL/RECOMMENDED READINGS

1. "Physical Chemistry" – P.W. Atkins
2. "Pesticide Formulation and Adjuvant Technology" – Chester L. Foy
3. "Agrochemical Discovery: Insect, Weed and Fungal Control" – John J. Beck
4. Journal Articles from Pest Management Science**,** Journal of Agricultural and Food Chemistry
5. K.H. Buchel - "Chemistry of Pesticides" Classic text explaining the chemistry, mode of action, and environmental aspects.
6. K.S. Birdi- "Surface Chemistry"
7. B.D. Khosla -Practical Physical Chemistry
8. S.S. Balpande- Laboratory Manual for Soil and Agrochemical Analysis
9. Fundamentals of Enzymology: Nicholas Price & Lewis Stevens

KEYWORDS: Physicochemical Properties of Pesticides, Formulation-toxicant interactions, Photochemical transformation of pesticides, Kinetics of Enzyme, Kinetics of Enzyme

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE – 03

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Analytical Techniques in Pesticide analysis	**4**	**2**	**0**	**2**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- To understand the principles behind preparing standard solutions, analytical reagents, qualitative reagents, and indicators.
- To Learn to construct standard curves essential for titrimetric and analytical applications.
- To learn the fundamentals and practical applications of separation methods including solvent extraction, thin layer chromatography (TLC), paper chromatography, and column chromatography.
- To gain insight into the applications of instrumental techniques like Ultraviolet-visible (UV-Vis) spectroscopy, infrared (IR) spectroscopy, atomic absorption spectroscopy (AAS), and mass spectrometry (MS)
- To understand how these methods are applied in pesticide formulation analysis and quality control.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Learn chromatography (TLC, paper, and column methods) to effectively isolate and identify agrochemical compounds from environmental and food samples.
- Critically Evaluate Analytical Methods
- Independently prepare reliable standard solutions and reagents required for a variety of analytical and titrimetric analyses in pesticide assessment.
- Analyze complex data sets, making informed decisions about method suitability and analytical outcomes.

SYLLABUS OF DSE- 03

THEORY COMPONENT-

UNIT 1: **(6Hours)**

Preparation of Solutions for Analytical and Titrimetric Applications:

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation- reduction and complexometric titration.

UNIT 2: **(8 Hours)**

Chemical analysis in Pesticide formulation: Titrimetric Methods: Acid-base,non-aqueous, iodimetric titration, oxidation-reduction (redox), precipitation and complexometric titrations

UNIT 3: **(6 Hours)**

General methods of characterization, separation and purification: Agrochemical compounds from soil, food stuff etc, Solvent extraction, Thin layer chromatography, paper chromatography and column chromatography

UNIT 4: **(10Hours)**

Instrumental analysis in Agro-chemistry:Applications of gas chromatography and liquid chromatography. Applications of Ultraviolet-visible spectroscopy, infrared spectroscopy, Atomic absorption spectroscopy, Mass spectrometry.

PRACTICAL COMPONENT (60Hours)

1. Extraction of pesticides from water samples using immiscible organic solvents.
2. Extract pesticide residues from soil using a solvent mixture.
3. Extraction from Leafy Vegetables (Spinach/Cabbage)
4. Extract Cleanup using Solid Phase Extraction (SPE)
5. To identify and compare multiple pesticides by determining their **$R_f$values** using **TLC** with suitable **mobile phases** and **visualization methods**. (e.g., Malathion, Carbaryl, Atrazine,
   2,4-D, Endosulfan)
6. Quantitative analysis of Pesticides using UV-Vis spectroscopy
7. To verify Beer-Lambert's law and prepare a calibration curve for a pesticide that absorbs in the UV-visible range (e.g., malathion**,** carbaryl**,** 2,4-D**, or** glyphosate**).**

8. To identify the functional groups**,** present in pesticide samples using Fourier Transform Infrared (FTIR) spectroscopy by analyzing their characteristic absorption bands.
9. To identify the structure of a pesticide for which mass spectra data is provided.

ESSENTIAL/RECOMMENDED READINGS

1. R.J Cremlyn, Agrochemicals: Preparation and mode of Action, 2nd Edition, Wiley Blackwell publishers, New Jersey (1991).
2. S.M Khopkar, Concepts in Analytical Chemistry, 3rd Edition, New Academic Science, New York (2008).
3. Willard, Merittee and Dean, Instrumental methods of Analysis, 5th Edition, Van Nostrand Publishers, Newyork (1974).

KEYWORDS: Analytical Applications, Titrimetric Applications, Chemical analysis in Pesticide formulation, Separation and purification techniques, Instrumental analysis in Agro-chemistry

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER –VIII

BSc. (Hons)Applied Life Sciences with Agrochemicals and Pest Management

Swami Shraddhanand College

DISCIPLINE SPECIFIC CORE COURSE – 02

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Agrochemical for Fungi, Nematodes, and Weeds: DSC 08	**4**	**3**	**0**	**1**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- Learners will gain knowledge about agrochemicals used for the control of fungi, nematodes and weeds.
- To study interactions of fungi, nematodes, and weed species in agricultural systems.
- To understand how these organisms, affect crop health and yield.
- Understand the biochemical and physiological mechanisms by which these chemicals control pest populations.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Articulate the modes of action for various agrochemical agents and explain how these mechanisms disrupt the life processes of pests.
- Develop strategies for minimizing adverse effects through careful selection, timing, and application of agrochemicals.
- Learners will explain, compare, and critically assess the major classes of agrochemicals (fungicides, nematicides, and herbicides) and their specific modes of action.

SYLLABUS OF DSC- 08

THEORY COMPONENT-

A. FUNGICIDES

UNIT 1: **(16Hours)**

Preparation, properties, uses, structure-activity relationship and mode of action of selected fungicides: Organophosphorus compounds and dithiocarbamatesPolyhalogenalkanes, sulfenyl compounds, phenols, quinones, carboxamides, carboximides.

Preparation, properties, uses, structure-activity relationship and mode of action of Azoles and other heterocyclics compounds as fungicides.

UNIT 2: **(8 Hours)**

A comprehensive view, with reference to two suitable examples of fungicides, for each of the followingMode of action

a) Membrane sterol biosynthesis
b) Lipid synthesis, transport, or membrane function
c) Respiration inhibitor
d) Nucleic acid metabolism

B. NEMATICIDES

UNIT 3:(6 Hours)

Preparation, properties, usesand mode of action of selected Nematicides: halocarbons, organophosphorus compounds, carbamates.

C. HERBICIDES

UNIT 4: **(15Hours)**

Properties, uses, structure-activity relationship and mode of action of phenoxyalkanoic acids, carbamates and substituted phenylureas, sulfonylureas

Properties, uses, structure-activity relationship and mode of action of triazines, pyridinium compounds,imidazolinones and dinitroanilines.,

Herbicide safeners and Synthetic plant growth regulators

A comprehensive view, with reference to suitable examples of herbicides, for each of the followingMode of action

a) Inhibition of Photosynthesis at PS II and PSI
b) Inhibition of Cellulose Synthesis
c) Inhibition of Microtubule Assembly

PRACTICAL COMPONENT (30Hours)

Synthesis of pesticides /analogues/intermediates

1. Preparation of 2,4-dichlorophenoxy acetic acid herbicide or its synthetic analogues (*any one* of the following)
    a) 4-chlorophenoxy acetic acid
    b) 4-methylphenoxy acetic acid
    c) 2-methylphenoxy acetic acid
2. Preparation of ethyl ester or butyl ester of any one of phenoxy acetic acid mentioned in experiment-1.
3. Preparation of 2-naphthoxyacetic acid (BNOA or β-naphthoxyacetic acid)
4. Preparation of Dithiocarbamate fungicide analogous from aromatic/aliphatic amine and separated as sodium /zinc/ manganese salt.
5. Preparation of Zineb (Z)
6. Preparation of urea derivative from phenylisocynate and aniline.
7. Preparation of thiourea derivative from phenylisothiocynate and aniline.
8. Preparation of benzimidazole/2-benzylimidazole /2-Methylbenzimidazole
9. Preparation of Maleic anhydride -an intermediate for agrochemicals
10. Writing the assigned an in-depth analysis of at least three fungicides /Nematicide/Herbicides to be allotted by the instructor. It must cover the detailed aspects of: Chemical Structure, Uses, Mode of Action, Toxicity and GHS labelling, Human Health Implications.

ESSENTIAL/RECOMMENDED READINGS

1. Audus, L.J. (1964), The Physiology and Biochemistry of Herbicides, Academic Press.

2.Bell, C.V. and Alford, D.V. (2000), _Pest and Disease Management Handbook, British Crop Protection Council; Wiley-Blackwell

3.Buchel, K.H. (Ed.) (1992), Chemistry of Pesticides, John Wiley & Sons

4. Copping, L.G., Hewitt, H.G. and Leonard, G.C. (1998), Chemistry and Mode of Action of Crop Protection Agents, Royal Society of Chemistry.

5. Cremlyn, R.J. (1990), Pesticides: Preparation and Mode of Action, John Wiley & Sons, U.K

6. Kearnay, P.C. and Kaufman, D.D. (1975), Herbicides: Chemistry, Degradation and Mode of Action_ (Vols. I, II), Marcel Dekker.

7. Kramer, W.K. and Ulrich, S. (2007), Modern Crop Protection Compounds,
Wiley-VCH Verlag GmbH

8. Metlosky, G.,Nadasy, M. and Andriska, V. (1988), Pesticide Chemistry,
Elsevier

9. Nene, Y.L. and Thapliyal, P.N. (1989), Fungicides in Plant Disease Control,
India Book House

10. Roy, N.K. (2002), Chemistry of Pesticides, CBS Publishers, New Delhi.

11. Unger, T.A. (1996), Pesticide Synthesis Hand Book, William Andrew.

12. Vyas, S.C. (1984),Handbook of Systemic Fungicides, Tata McGraw Hill.

KEYWORDS: Fungicides, mode of action of fungicides, Nematicides, mode of action of herbicides, Herbicide safeners, Synthetic plant growth regulators

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 04

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Environmental health and Agrochemicals	**4**	**2**	**0**	**2**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- Understand the mechanisms of pesticide entry and dispersion in environmental compartments.
- Explore the interactions between pesticide residues and soil/water/microbial systems.
- Assess the toxicological and ecological implications of pesticide residues.
- Implications of pesticide persistence on human health.
- Impact of Pesticide Residues on Human Health and Society

Learning outcomes

The Learning Outcomes of this course are as follows:

- Describe the environmental pathways of pesticide residues in air, water, and soil.
- Analyze the physicochemical and biological processes governing pesticide degradation and transport.
- Evaluate the impact of pesticide residues on ecosystems, food safety, and public health.
- Persistence of pesticides in environment.
- Propose sustainable practices and policy interventions to mitigate agrochemical pollution.

SYLLABUS OF DSE- 04

THEORY COMPONENT-

UNIT 1: (6Hours)

Residues of Agrochemicals in the Atmosphere:

Entry pathways of pesticides into the atmosphere, Fate of Pesticides in the atmosphere, Transport of vapors, Precipitation, Impact of airborne residues, air quality and climate, effect of residues on human health

UNIT 2: (6 Hours)

Residues of Agrochemicals in Water system:

Nature and origin of pollution of aquatic systems, Point and Non-Point pollution. Runoff, leaching, and effluent discharge into water bodies, Physicochemical properties influencing aquatic fate (solubility, hydrolysis, photolysis). Dynamics of pesticides in aquatic environment. Toxicological effects on aquatic flora and fauna

UNIT 3: (6 Hours)

Pesticides residues in the Soil:

Absorption, Retention, Transport and Degradation of pesticides in the soil, persistence and half-life of various pesticide classes in soil. Effect on microorganisms and Consequent effect on the soil condition, Fertility, nutrient cycle and crop productivity. Interactions between pesticides and soil organic/inorganic matter

UNIT 4: (12Hours)

A Persistence of Pesticides in the Environment:

Low, moderate and high persistent pesticides, Persistent organic pollutants, Physical, chemical, biochemical and environmental factors affecting pesticide of persistence in the environment.

B Pesticide Dissipation and Fate in The Environment:

Various dissipation processes, Role of drift, volatilization, adsorption, desorption, runoff etc.in pesticide dissipation, Leaching and risk of groundwater pollution, Dissipation time (Half-life-DT50, DT90), Rate kinetics (1st order, 2nd order), Behavior and fate of pesticides in soil and crops.

C Impact of Pesticide Residues on Human Health and Society:

Direct and indirect exposure pathways in humans (food, water, air, occupational). Acute and chronic health effects (carcinogenicity, neurotoxicity, endocrine disruption, genotoxicity, skin sensitization, reproductive and developmental toxicity).

PRACTICAL COMPONENT (60Hours)

1. To study degradation of airborne pesticides when exposed to UV radiation.
2. To observe chemical degradation (hydrolysis and photolysis) of pesticides in water
3. To measure how different soils, retain pesticides through adsorption.
4. To determine the degradation rate and persistence of a pesticide in soil.
5. To analyze enzyme activity or nutrient availability in pesticide-treated soil.
6. To study whether washing, peeling, or boiling reduces pesticide residues and protects food quality.
7. Writing the assigned an in-depth analysis of at least three pesticides to be allotted by instructor. It must cover the detailed aspects of: Chemical Structure, Impact on environment and its persistence, Toxicity, Human Health Implications and GHS labelling

ESSENTIAL/RECOMMENDED READINGS

1. Ogwu, M. C., &Izah, S. C. (Eds.). (2023). One health implications of agrochemicals and their sustainable alternatives (Vol. 34). Springer Nature.

2. WHO (World Health Organ.), FAO (U. N. Food Agric. Organ.). (2019). Global situation of pesticide management in agriculture and public health: report of a 2018 WHO-FAO survey WHO, Geneva.
https://apps.who.int/iris/handle/10665/329971](https://apps.who.int/iris/handle/10665/329971)

3. Vaz Jr, S. (2019). Sustainable agrochemistry. Springer International Publishing, New York, US.

4. Naeem, M., Juan Francisco Jimenez Bremont, Abid Ali Ansari, &Sarvajeet Singh Gill. Agrochemicals in Soil and Environment.

5. Devi, P. I., Manjula, M., &Bhavani, R. V. (2022). Agrochemicals, environment, and human health. Annual Review of Environment and Resources, 47(1), 399-421.

6. Dowdall, C. M., & Klotz, R. J. (2016). Pesticides and global health: understanding agrochemical dependence and investing in sustainable solutions. Routledge. https://doi.org/10.4324/9781315422695

7. Yassi, A. (2001). Basic environmental health. Oxford University Press.

8. Akpan, G. E., Ndukwu, M. C., Etim, P. J., Ekop, I. E., &Udoh, I. E. (2023). Food Safety and Agrochemicals: Risk Assessment and Food Security Implications. In One Health Implications of Agrochemicals and their Sustainable Alternatives (pp. 301-333). Springer Nature Singapore.

9. Frumkin, H. (Ed.). (2016). Environmental health: from global to local. John Wiley & Sons.

10. Nriagu, J. O. (2019). Encyclopedia of environmental health. Elsevier.

11. Pretty, J. (Ed.). (2012). The pesticide detox: towards a more sustainable agriculture. Routledge.

12.Hamilton, D., & Crossley, S. (Eds.). (2004). *Pesticide residues in food and drinking water: human exposure and risks*. John Wiley & Sons.

13. Horrigan, L., Lawrence, R. S., & Walker, P. (2002). How sustainable agriculture can address the environmental and human health harms of industrial agriculture. Environmental Health Perspectives, 110(5), 445-456.

14.Schnoor, J. L. (Ed.). (1992). *Fate of Pesticides and Chemicals in the Environment*. John Wiley & Sons.

15. Shahamat U Khan. 1980. Pesticides in the Soil Environment (Editor: R. J. Wakeman) Elsevier.

KEYWORDS: Residues of Agrochemicals, Fate of Pesticides in the atmosphere, Toxicological effects, Transport and Degradation of pesticides, Persistence of Pesticides, Pesticide Dissipation in environmental

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE – 05

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Natural Pesticides: Biopesticides and Plant Toxins	**4**	**2**	**0**	**2**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- Define natural pesticide, including biopesticides and plant toxins.
- Differentiate between biopesticides and synthetic chemical pesticides.
- Identify common examples of biopesticides and plant-derived toxins.
  Analyze the advantages and limitations of using natural pesticides.
- Discuss the environmental and health benefits of biopesticides over synthetic pesticides.
- Evaluate real-world applications and case studies of natural pesticides in modern agriculture.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Demonstrate an understanding of biopesticides and plant toxins in pest control.
- Apply knowledge of natural pesticides to sustainable farming practices.
- Assess the role of biopesticides in reducing chemical pesticide dependency.
- Critically evaluate different biopesticide strategies for pest management.

SYLLABUS OF DSE- 05

THEORY COMPONENT-

UNIT 1: **(9Hours)**

Isolation, characterization, properties and mode of action of important groups of naturally occurring insecticides (pyrethroids, nicotinoids, rotenoids, limonoids, microbial macrolides).Sources of bio pesticides and extraction (ASE, SFE /solvent extraction)

UNIT 2: (5 Hours)

A Bacillus thuringiensis and nuclear polyhedrosis virus based insecticides and other biopesticides.

B Semi chemicals, insect hormones, insect growth regulators, feeding deterrents and repellents etc

UNIT 3 (4Hours)

Natural nematicides, fungicides, mollusicides and rodenticides

UNIT 4 (12Hours)

A Introduction to Plant Toxins Based on Plant Family

B Classification Plant Toxins Based on Chemical Structure

C Biological Activity and Mode of Action of Plant Toxins

PRACTICAL COMPONENT (60Hours)

1. Extraction by hydrodistillation, isolation of pure compounds, their characterization,
2. Extraction of tobacco leaves
3. isolation of nicotine and its identification,
4. Extraction of neem seed kernels, enrichment of azadirachtin, analysis of azadirachtin and its analysis.
5. To extract azadirachtin, a bio-pesticidal compound, from neem seeds using organic solvents.
6. To extract caffeine from tea leaves by solvent extraction method using dichloromethane.
7. To extract and estimate the amount of **allicin**, a bioactive compound, from fresh garlic using spectrophotometry.
8. Writing the assigned an in-depth analysis of at least three biopesticides to be allotted by instructor from different sources from theory portion. It must cover the detailed aspects of: Source, Chemical Structure, extraction /isolation from natural source, Uses, Advantages and disadvantages with respect to synthetic pesticides, Toxicity, Human Health Implications (if any), GHS labelling.

ESSENTIAL/RECOMMENDED READINGS

1. Alexander, M. (1999). Biodegradation and Bioremediation (2nd ed.). Academic Press.

2. Copping, L.G. (1996). Crop Protection Agents from Nature: Natural Products and Analogues. Royal Soc. Chem., London, 136.
3. Dev, S. &Koul, O. (1997).Insecticides of Natural Origin. Harwood Acad. Publishers.
4. Godfrey, C.R.A. (1995). Agrochemicals from Natural Products Marcel Dekker.
5. Hall, J.C., Hoagland, R.E. &Zablotowicz, R.M (2001). Pesticide Biotransformation in Plants and Microorganisms: Similarities and Divergences. ACS Symposium Series, 777. Washington, DC.
6. Hassal, K.A.(1990). The Biochemistry. Plenum Press.
7. Jacobson, M. (1965).Insect Sex Attractants. John Wiley & Sons.
8. Jacobson, M. (1970). Naturally Occurring Insecticides. John Wiley & Sons.
9. Khan, S.U. (1980). Pesticides in the Soil Environment. Elsevier.
10. Leahey, J.P. (1985). The Pyrethroid Insecticides. Taylor & Francis.
11.Matsumura, F. (1975). Toxicology of Insecticides. Plenum Press.
12. Menzie, C.M (1980). Metabolism of Pesticides. Update III US Fish and Wildlife Service Special Scientific Report.
13. Parmar, B.S. &Devakumar, C (1990). In: Botanical and Biopesticides. Westvill Publ. House.
14. Racke, K.D., Skidmore, M.W., Hamilton, D.J., Unsworth, J.B., Miyamoto, J. &Cohen, S.Z. (1997). Pesticide Fate in Tropical SoilsPure and Appl. Chem., 69(6), 1349–1371.
15. Mtewa, A. G., Egbuna, C., & Rao, G. M. N. (Eds.). (2021). Poisonous plants and phytochemicals in drug discovery / edited by Andrew G. Mtewa, (First edition.). John Wiley & Sons
16. Osman, A. M. G., Chittiboyina, A. G., & Khan, I. A. (2013). Plant toxins. In *Foodborne infections and intoxications* (pp. 435-451). Academic Press.
17. Keeler, R. F., &Tu, A. T. (Eds.). (1991). *Toxicology of plant and fungal compounds*. M. Dekker.
18. Dauncey, E. A., & Larsson, S. (2018). *Plants that kill: A natural history of the world's most poisonous plants*. Princeton University Press.

KEYWORDS: Bio pesticides, Bacillus thuringiensis, Nuclear polyhedrosis virus, Semi chemicals, Insect growth regulators, Natural nematicides, mollusicides and rodenticides

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 06

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Pesticide Formulation and Application Equipment	**4**	**2**	**0**	**2**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- Identify various types of pesticide formulations (e.g., emulsifiable concentrates, wettable powders, granules, suspension concentrates) and discuss their specific characteristics, advantages, and limitations.
- Analyze the chemical and physical properties that affect the formulation's stability, efficacy, and compatibility.
- Importance of pesticide Labelling
- Analyze how the choice of formulation impacts the selection and performance of application equipment.
- Describe the function and importance of key components in application equipment, such as nozzles, pumps, and pressure mechanisms.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Classify different pesticide formulations with an explanation of their components and respective functions
- Demonstrate Knowledge of Pesticide Formulation and labelling

- Select suitable pesticide application equipment based on specific crop requirements, target pest types, and environmental conditions.
- Ensure Safety and Compliance assurance requirements.

SYLLABUS OF DSE- 06

THEORY COMPONENT-

UNIT 1: **(7 Hours)**

Introduction and Types of Pesticide formulations:

A Definition, purpose of formulations, Important formulation terms: Active Ingredient, Inert Ingredient, Phytotoxicity, Adjuvant, Carrier, surfactants, emulsifiers, stabilizers, wetting agents, Spray Mix Terminology: solution, suspension, emulsion

B International codes for the formulation type.Wettable powders, soluble powder, solutions, emulsifiable concentrates, aerosols, dusts and granules. Controlled Release Pesticides, Bait. Advantages and disadvantages of individual pesticide formulation

UNIT 2: **(12 Hours)**

Key aspects for creating a formulation and Conventional formulation:

A Type of surface, Training and equipment, Runoff or drift, Safety to people, animals, and the environment, Habits of the pest, Consideration of mixed pesticides for their capabilities and incompatibilities

B Dusting, Powders/ Dust Formulations (DP), Granules (GR), Water Dispersible Powders/Wettable powders (WDP/WP), Soluble Concentrates (SC), Emulsifiable concentrates (EC), Ultra Low volume (ULV) with respect to their ingredients, advantages and disadvantages.

UNIT 3: **(4 Hours)**

Introduction to pesticide Application Equipment:

Overview of pesticide application equipment (with few selected examples), each tailored to type of the formulation.

1. Dusters: Manually and Power Operated Dusters
2. Sprayers: Knapsack Sprayers, Hydraulic Sprayers, Aerial Sprayers (Aircraft or drones)

3. Modern trends in pesticide application with Precision Application Equipment: Technological advancement with GPS-guided sprayers and drone-based application systems
4. Types of nozzles: Function of nozzles with different size and hole diameter available as an attachment with these sprayers.

UNIT 4: **(7 Hours)**

Understanding pesticide Label and Labeling:

Definition, purpose of Label and Labeling, Common Terms Used in Pesticides Labels, Precautionary Statements, Direction for Use Environmental Hazards, Color coding Information on the label Symbols,Toxicity information/ statements, Pictograms, Labels (GHS) warning statements, Information about type of formulation, Name of pesticide, active and inert material, Name of manufacturer, Quantity

PRACTICAL COMPONENT **(60Hours)**

1. Preparation of Emulsifiable concentrate (EC) formulation of given organic compound as oil in water emulsion(O/W).
2. Preparation of EC formulation: Emulsifiable concentrate of neem oil.
3. Preparation of standard hard water.
4. To determine the emulsion stability of given EC formulation.
5. Determination of bulk density of pesticidalwettable powder (WP).
6. Preparation of WP formulation.
7. Volumetric determination of acidity/ alkalinity of WP.
8. Preparation of Suspension Concentrate (SC) formulation.
9. Determination of wettability of pesticidal WP / Dust/SP.
10. To draw pictograms and indicate:
    a. Advice, Warning and their meaning
    b. Colour Codes and their meaning

11. Write the colour identification band and warning symbol as per toxicity Data (LD_{50}) following Government of India Recommendations (*see***reference -2**)

12. Each student to be assigned project for designing the label manually for any five pesticides. It must cover the detailed aspects of: Pesticide formulation, Manufacturers name, Quantity of Active and inert ingredient, Pictograms/GHS labelling/Toxicity statement(s), Handling instruction, Any other information required for label

13. Student to be demonstrate / visit to the manufacturing unit for pesticide Application Equipment

ESSENTIAL/RECOMMENDED READINGS

1. Agrochemicals-Pesticide formulations | IUPAC https://agrochemicals.iupac.org
2. Report of the committee on manner of labelling of pesticides as per toxicity Dated 09 August,20I9 Ministry of Agriculture & Farmers Welfare Government of India No. 24-01/2019-ClR.Ihttps://ppqs.gov.in/sites/default/files/public_notice_0.pdf
3. Cardarelli, N.F. (2018). Controlled Release Pesticides Formulations.CRC Press.
4. Foy, C.L., & Pritchard, D.W. (1996). Pesticide Formulation and Adjuvant Technology. CRC Press.
5. Hall, F.R., Berger, P.D., & Collins, H.M. (1995). Pesticide Formulations and Application Systems (Vol. 14).
6. Knowles, D.A. (1998). Chemistry and Technology of Agrochemical Formulations. Springer.
7. Parmar, B.S., &Tomar, S.S. (2004). Pesticide Formulation - Theory and Practice. CBS Publishers & Distributors.
8. Wade, R. (1973). Pesticide Formulation. Dekker, Inc.
9. Wade, V.V., Sugavanam, B., &Khetan, S.K. (1998). Pesticide Formulation. New Age International Publishers.
10. Ware, G.W. (1994). The Pesticide Book (4th ed.). W.H. Freeman: Fresno, CA.

KEYWORDS: Pesticide formulations, Conventional formulation, pesticide application equipment,Pesticide Label and Labeling, Suspension Concentrate formulation

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SKILL ENHANCEMENT COURSE (SEC-1): Advanced Software Utilities for Chemists

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Software Utilities for Chemists **SEC-1**	**2**	**1**	**0**	**1**	**12^{th} class with science**	NIL

Course objectives

Course Objectives:

- To develop basic understanding of important software utilities *Gnuplot* and using this tool for presentation of data in graphical form for research purpose.
- To develop basic understanding of software utilities for designing and formatting chemical structures.
- To develop a basic understanding of functioning of a Large Language Model utility; *ChemCrow* for **C**hemists.

Learning outcomes

After completing the course, the students will be able to:

- Develop standard research quality graphs and analyze the graph for understanding acquired data.
- Use software utilities for designing chemical structures in varied representations for example, in research articles and presentations.
- Use Large Language Model utility; *ChemCrow* for applying molecule tool, safety tool, and chemical reaction tool for analyzing chemical reaction and scientific data for literature survey.

THEORY

UNIT 1: Software Utilities for Chemists **(15 Hours)**

Gnuplot Software Utility

Graphical analysis and visualization of computational data. Need and limitations of Graphical analysis. Introduction to *Gnuplot* plotting tool, a command-driven interactive function and data plotting program.

Basic *Gnuplot* commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file. Locations on a graph, Editing and Styling plots (plot ranges, line styles, colours, fonts, terminal types). Use of multiple axes and multiple plots in a single page.

Basics of three-dimensional plots, generating surface and contour plots, plotting data from a file. Understanding colour spaces, defining palettes, creating coloured graphs with palettes. Advanced plotting concepts; Multiplot, Higher math and special occasions, Mathematical Functions and curve fitting. Exporting graphs to file.

Software Utilities for drawing Chemical Structure and ROSHAMBO Utility

Introduction to software utilities for designing molecules species and representation of chemical reaction and ROSHAMBO utility for molecular alignment and 3D similarity scoring.

Large Language Model utility: ChemCrow

Introduction to *ChemCrow*; *General tool*, *Molecule tool*, *Safety tool NameRXN*, *RXNPredict*, *RXNPlanner* tool for using the software for designing chemical structure, literature survey, exploring safety of materials and prediction and planning reactions.

Practicals: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

1. Plotting graphs using Gnuplot
   - (i) Installing Gnuplot and plotting simple 2-D plots: linear, sine, cosine, exponential
   - (ii) Ideal gas isotherms
   - (iii) Pressure-volume curves of van der Waals gas (van der Waals isotherms)
   - (iv) Planck's distribution law
   - (v) Radial distribution curves for hydrogen like orbitals
   - (vi) Maxwell-Boltzmann distribution curves as function of temperature and molecular weight
   - (vii) Data from phase equilibria studies.
   - (viii) Graphical solution of equations.
   - (ix) Simulation of pH metric titration curves.
   - (x) Simple 3D functions such as sin(x)*cos(y)
   - (xi) Parametric plots in spherical polar coordinates
   - (xii) Probability density surface as a function of angle for Hydrogen atom

2. Drawing chemical structures of various compounds (aliphatic, aromatic, heterocyclic with different functional groups, using Free, Open Source, Proprietary and Online software utilities i.e. ACD Chemsketch and 3-D viewer, ChemDraw, ChemDraw online & ROSHAMBO utility.
3. Exploring organic name reactions in ChemCrow

Essential/recommended readings

Theory:

1. Janert P. K., (2010) Gnuplot in Action, Manning Publications Co., Greenwich, CT.
2. Phillips L., (2012) Gnuplot Cookbook, Packt Publishing, Birmingham U.K.
3. Moore B.G., Orbital Plots Using Gnuplot, J. Chem. Edu., 77 (6), (2000) 785-789.
4. Atwi R., Wang Y., Sciabola S., and Antoszewski A., ROSHAMBO: Open-Source Molecular Alignment and 3D Similarity Scoring, J. Chem. Inf. Model., 64, (2024) 8098−8104.
5. https://fitzkee.chemistry.msstate.edu/sites/default/files/ch8613/ibm-gnuplot.pdf
6. https://fitzkee.chemistry.msstate.edu/sites/default/files/bootcamp/2022/session-08_gnuplot-tutorial.pdf
7. https://emleddin.github.io/comp-chem-website/Analysisguide-gnuplot.html
8. https://www.acdlabs.com/resources/free-chemistry-software-apps/chemsketch-freeware/
9. https://chemaxon.com/marvin
10. https://www.insilicochemistry.io/tutorials/foundations/gpt-4-for-chemistry#h.kfv6wyq239nc

Practical:

1. Janert P. K., (2010) Gnuplot in Action, Manning Publications Co., Greenwich, CT.
2. Phillips L., (2012) Gnuplot Cookbook, Packt Publishing, Birmingham U.K.
3. Moore B.G., Orbital Plots Using Gnuplot, J. Chem. Edu., 77 (6), (2000) 785-789.
4. Atwi R., Wang Y., Sciabola S., and Antoszewski A., ROSHAMBO: Open-Source Molecular Alignment and 3D Similarity Scoring, J. Chem. Inf. Model., 64, (2024) 8098−8104.
5. https://fitzkee.chemistry.msstate.edu/sites/default/files/ch8613/ibm-gnuplot.pdf
6. https://fitzkee.chemistry.msstate.edu/sites/default/files/bootcamp/2022/session-08_gnuplot-tutorial.pdf

7. https://emleddin.github.io/comp-chem-website/Analysisguide-gnuplot.html
8. https://www.acdlabs.com/resources/free-chemistry-software-apps/chemsketch-freeware/
9. https://chemaxon.com/marvin
10. https://www.insilicochemistry.io/tutorials/foundations/gpt-4-for-chemistry#h.kfv6wyq239nc

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SKILL ENHANCEMENT COURSE (SEC-2): Lab-Based Learning: Analytical Instruments

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Lab-Based Learning: Analytical Instruments **SEC-2**	**2**	**1**	**0**	**1**	**12^{th} class with science**	NIL

Course objectives

Course Objectives:

- To learn about the fundamentals of separation techniques employed in organic synthesis and the purification of organic compounds.
- To understand instrumentation (hardware/software) employed in the analysis and identification of organic compounds.
- Hands-on training on spectroscopic instruments and separation techniques employed in organic synthesis.

Learning outcomes

After completing the course, the students will:

- gain experience in various separation techniques typically employed for monitoring reaction progress and the purification of pure compounds from a mixture.
- work independently on sophisticated equipment used in organic synthesis, correlating with the principle and the instrumentation part.

THEORY

UNIT 1: Separation and Analytical Instruments **(15 Hours)**

Thin Layer Chromatography

Principle of using TLC in monitoring organic reactions, Polarity of Solvents, Retention factor, Principle and application of HP TLC.

Column Chromatography

Theory of Column Chromatography, Gradient Solvent Systems, Application of Column Chromatography in purification of mixtures.

UV-VIS Spectroscopy

Basics and applications of UV-vis spectroscopy, Instrumentation of UV-vis spectroscopy, Applications of UV-vis spectroscopy.

Optical Rotation

Importance of optical activity, Instrumentation of Polarimeter, Sample preparation, Recording Optical rotation of organic compounds.

Practicals: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

1. To determine the number of organic compounds present in the given mixture by TLC, and calculate their respective R_f values.
2. To determine the relative polarities of a set of given organic compounds by comparing their R_f on TLC.
3. To separate a mixture of two or more non-polar organic compounds by column chromatography using a gradient solvent system (Hexanes/EtOAc).
4. To separate a mixture of two or more medium/high polarity organic compounds by column chromatography using a gradient solvent system (MeOH/DCM).
5. Hands-on training on running a UV-vis spectroscopy and sample preparation.
6. To verify the linear relationship between absorbance and concentration using a coloured organic compound.
7. To investigate the effect of solvent polarity on the keto-enol equilibrium of acetylacetone by analyzing UV-Visible absorption spectra.
8. To study the effect of pH on the UV-Vis spectrum of an indicator (e.g., methyl orange).
9. Hands-on training on running a polarimeter and sample preparation.
10. To measure the optical rotation of a pair of enantiomers.

Essential/recommended readings

Theory:

1. Furniss B. S., Hannford A. J., Smith, P. W. G., Tatcheli, A. R., “Vogel's Textbook of Practical Organic Chemistry” 5th ed., Longman Scientific &Technical
2. Kemp W., 'Organic Spectroscopy', 3rd ed., Palgrave, New York (1991).

3. Willard H. H., Merritt Jr. L. L., Dean J. A., Settle F. A. S., "Instrumental Methods of Analysis", 7th Ed., Wadsworth, 2009, Cengage Learning India Pvt. Ltd. Fifth Indian reprint by CBS Publishers & Distributors Pvt. Ltd.
4. Silverstein R. M., and Webster F. X., "Spectrometric Identification of Organic Compounds", 6th ed., John Wiley & Sons, New York (1998).
5. Skoog D. A., Holler F. J., and Crouch S. R., "Principles of Instrumental Analysis", 6th ed., Thomson Brooks/Cole, Cengage Learning, New Delhi (2007).

Practical:

1. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy.
2. Donald A. McQuarrie and John D. Simon, Physical Chemistry: A Molecular Approach.
3. J. Michael Hollas, Modern Spectroscopy.
4. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis.
5. Donald L. Pavia, Gary M. Lampman, George S. Kriz, Introduction to Spectroscopy.
6. Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
7. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
8. Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
9. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.