UNIVERSITY OF DELHI

CNC-II/093/1/EC-1275/25/07

Dated: 31.07.2025

NOTIFICATION

Sub: Amendment to Ordinance V

(ECR 07-9/ dated 23.05.2025)

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

Add the following:

The syllabi of Semester-I/II of the following Departments under Faculty of Inter-Disciplinary & Applied Sciences based on Postgraduate Curriculum Framework 2024, are notified herewith for the information of all concerned:

DEPARTMENT	SYLLABI	ANNEXURE
Biochemistry	M.Sc. Biochemistry	1
Genetics	M.Sc. Genetics	2
Microbiology	M.Sc. Microbiology	3
Plant Molecular Biology	M.Sc. Plant Molecular Biology and Biotechnology	4
Electronic Science	1. M.Sc. Electronics 2. M.Sc. Informatics	5

REGISTRAR

Annexure-1

UNIVERSITY OF DELHI

MASTER OF SCIENCE

(Biochemistry)

(Effective from Academic Year 2025-26)

PROGRAMME BROCHURE

Syllabus as approved by
Committee of Courses on 11 March 2025

I. About the Department

I.1 Historical Background and Department Highlights

The Department of Biochemistry, a vibrant and premiere unit of the University, was established in 1983. Initially, the Master's course in Biochemistry was offered as a guest course at the Vallabhbhai Patel Chest Institute (VPCI), University of Delhi. In 1986, under the pioneering leadership of its founding father Prof. B.K. Bachhawat, the course moved full-fledged to South Campus and research activities took wing, heralding a new beginning and glorious future. The activities of the department revolve around the central theme of "Development of molecular strategies to combat various human diseases". The Department has received Extramural grants from DBT, DST, ICMR, CSIR, and DRDO, as well as intramural grants from the University of Delhi for research and infrastructure. The Department has also been funded under the DST-FIST, UGC-SAP and DU-DST PURSE programs. Every faculty member has well-equipped laboratory for research. The department has the Central Instrumentation Facility that houses high-end equipment as well as equipment routinely used for dissertation and research work.

One of the commendable contributions of the department has been the creation and sustenance of rigorous, dynamic and vibrant teaching and research programme that imparts conventional and new knowledge in an innovative manner, which ensures that fresh, young minds are trained and oriented to create newer knowledge in turn. In the department, teaching over the years has reached impeccable standards and research attained world-class quality. We boast of a world class faculty equipped with state-of-the art facilities that constantly churn out productivity – be it extremely well-trained students who find placement in various spheres of the professional world; research publications that are well cited; patents or technology that have reached the market (diagnostic kits); or technologies that have shown great potential for the near future (vaccine, gene therapy, drug, drug delivery). Our faculties have carved out a niche for themselves on the scientific arena and have won several awards, accolades and honors. Our students are equally productive and attain success regularly in all possible ways.

I.2 About the Programme

The M.Sc. programme in Biochemistry endeavours to provide students with excellent training in Biochemistry emphasizing on solid background of basic concepts as well as rapid advancement in the field. As per the NEP-2020 guidelines, the M.Sc. programme can be of two years full time or one-year full time depending upon the student's choice and his B.Sc. course duration. Hence, the course curriculum is designed accordingly for both the options as elaborated later. In addition to theoretical knowledge, considerable emphasis is given on hands on experience in the forefront areas of Biochemistry and Biotechnology through practical training in masters' laboratory. The second year of the two-year programme or the only one-year programme has three tracks which are i) only coursework, ii) coursework and research and iii) coursework with emphasis on research. To augment hands on research training in the research track programmes, an important feature pertains to the inclusion of project work and dissertation, that will allow students to get hands-on-experience in tools and methods used in Biochemistry and Biotechnology in specific labs allotted to students under the supervision of a mentor. The emphasis is to expose students to various aspects pertaining to research including the habit of scientific reading, research methodology, analytical ability, organizational capability, independent thinking, experimental design and execution capability and scientific writing. Another outstanding feature that defines the programme and inculcates self-learning is the two courses (one in each semester of the first year in two-year programme), in which students are required to present in open forum for collective evaluation by the departmental faculty members. In the first year, students will be required to present seminars on important scientific topics and concepts after critical review of the scientific literature. In the second year of the two-year programme or in the only one-year programme with research, they are required to present update on the area of their dissertation research. This aspect of the programme helps students learn how to critically assess research papers, distil the best of the information and present the same in a concise and clear manner. The enlightening exercise will give them experience of public speaking and instil confidence. Students can also take advantage of the various elective courses on human diseases (infectious diseases and life-style disorders) to align themselves with the central theme of the department and equip better for future research in aspects of human diseases and disorders, the need of the hour in the country. Students who join the programme from non-biochemistry background in life sciences can take advantage by opting for the courses on Intermediary Metabolism or Developmental biology. The course also offers generic elective courses in Enzymes and metabolic pathways and Food and nutritional biochemistry that will also provide students, especially from other programmes in the University, an overview of the biochemical principles and concepts in various aspects of the subject.

In addition, the department regularly organizes seminars by national and international researchers to expose the students to a repertoire of scientific areas and scientific methodology to complement the courses in the programme. Although summer training is not a compulsory part of the curriculum, students are encouraged to undergo summer training in the department or other institutions during summer vacation, especially through national fellowships like those provided by the three Indian academies of Sciences. The department has separately allocated funds for educational tours to support their visits to various institutions / universities / industries. Students are encouraged to attend national conferences to expose them to the scientific community to learn the latest developments in science. Students are also encouraged to present posters and co-author papers and reviews. The department also organizes symposiums and conferences inviting eminent scientists across the country. For a holistic development, several cultural and sports activities are also organized round the year.

I.3 About Post Graduate Attributes

It is expected that at the end of the programme, each student is independent in their thought processes and can make an informed choice about their subsequent career. The program is expected to motivate students for higher education, especially research, while providing trained manpower for biotechnology industry as well. The students are expected to be able to apply biochemical principles to understand various complex processes in life sciences and provide biotechnological solutions to combat various human diseases. They are expected to be ethically sound and ready for the next phase of their development.

I. 4 About the process of course development involving various stakeholders at different stages

For the design of curriculum, selection of courses and drafting of syllabus for each course, suggestions from stakeholders were obtained at each stage. The course structure was initially framed in a faculty meeting and suggestions were sought from stakeholders that included the current M.Sc. students of the department and students who passed out in the last few years.

Based on the suggestions, the course structure was re-framed and syllabus for each course was drafted. Subsequently, the drafts went through multiple rounds of revisions. The revised draft was deliberated in a meeting of the Committee of Courses, their suggestions were incorporated and the final draft was prepared.

II. M.Sc. Programme Details:

Programme Objectives (POs):

The proposed programme shall be governed by the Department of Biochemistry, Faculty of Interdisciplinary and Applied Sciences, University of Delhi South Campus, New Delhi-110021. The specified program will lead to the award of a M.Sc. degree in Biochemistry. Students will be offered advanced level theory and practical courses in subjects like proteins and enzymes, cellular signals, immunology and immune-techniques, molecular biology, recombinant DNA technology, advanced techniques in biochemistry and multi-omics technology. The emphasis is on hands-on training of students. The research track programmes include work by students in research laboratories to carry out projects under the supervision of faculty members in addition to two practical courses in the first year. Before students initiate dissertation research projects, they will also be trained adequately in the various basic tools, techniques and instrumentation in specific research laboratories. Students are also required to present critical reviews on various current and significant topics in seminars. In the process they develop oratory and writing skills. In keeping with the objectives of the department, elective courses have also been included to impart knowledge in infectious diseases and life style disorders, in intermediary metabolism and developmental biology. The department also offers a generic elective course on enzymes and metabolic pathways and food and nutritional biochemistry for interested students across the University.

The department strives to achieve the following programme objectives:

- The foremost objective of the programme is to empower students with clear understanding of the basic concepts of biochemistry and provide them knowledge of the recent advances so that they can independently assess the vast scope in the field.
- The programme aims to train students to enable them to apply biochemical principles, theoretically and experimentally, to understand various complex life processes, while providing biotechnological solutions to combat various human diseases.
- It is expected that at the time of completion of the programme each student is confident and independent in their thought processes and can make an informed choice about their subsequent career.
- The program is expected to motivate students for higher education, especially research and provide trained manpower for biotechnology industry.
- They are expected to be ethically sound and ready for the next phase of their development, skilled in the art of self-reading, oration and scientific writing.

Programme Specific Outcomes (PSOs):

A post-graduate student upon completion of the programme is expected to gain the following attributes:

- In-depth knowledge of Biochemistry with inter-disciplinary perspective of other branches of life sciences.
- Competence for research and innovation in Biochemistry as a skilled experimentalist.
- Analytical and problem-solving skills with regard to biochemical principles of life processes and technologies for combating human diseases.
- Critical thinking about the concepts in Biochemistry and ability to critically review scientific literature for development of new theories and testable hypothesis.
- Capacity for decision making with regard to scientific progress, personal development and career choice.
- Ability to work independently, while still promoting teamwork and collaboration skills.
- Oratory (public speaking), scientific conversation and writing skills.
- Leadership and organizational skills.
- Demonstration of integrity, honesty, ethical behavior and sense of responsibility.
- Appreciation of diversity in scientific community and responsibility towards society and nation.
- Environmental awareness vis-à-vis bio-waste generation, disposal and management and safety and security issues.

Programme Structure:

As per the NEP-2020 guidelines, the M.Sc. programme will be offered as either a two-year programme or a one-year programme depending on the duration of the B.Sc. course of the student and the choice of the student. A student who has pursued 4-year Undergraduate degree in Biochemistry and allied subjects will be eligible to opt for a one-year M.Sc. programme while a student with 3-year undergraduate degree in Biochemistry and allied subjects will be eligible only to opt for a two-year M.Sc. programme.

Two-year M.Sc. programme will have a total of 88 credits with 22 credits in each semester. The second year of the programme will have three options and the student will have to opt for any of the options out of i) PG with only coursework, ii) PG with coursework and research and iii) PG with coursework and more emphasis on research. The credit scheme for the course is tabulated below.

The one-year M.Sc. programme will have a total of 44 credits with 22 credits in each semester. The programme will have three options and the student will have to opt for any of the options out of i) PG with only coursework, ii) PG with coursework and research and iii) PG with coursework and more emphasis on research. However, the third option (PG with coursework and more emphasis on research) will only be offered to the students with B.Sc. (H) Biochemistry degree. The credit scheme for the course is tabulated below.

SEMESTER-WISE PROGRAM STRUCTURE OF M.Sc. BIOCHEMISTRY COURSE
(NEP-PGCF)

First year (common in Program Structure 1, 2 and 3)

Semester-1

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-01: Proteins and Enzymes	3	1	0	4
DSC-02: Basic Techniques in Biochemistry	0	4	0	4
DSC-03: Emerging areas in Biochemistry	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-01: Developmental Biology	3	1	0	4
DSE-02: Intermediary Metabolism	3	1	0	4
Generic Elective (GE) courses*				
GE-01: Food and Nutritional Biochemistry	3	1	0	4
Skill enhancement course (SEC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SEC-01: ICT tools for Biochemistry	0	2	0	2
Research Methods/ Tools/ Writing	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

* *(a student can opt for either two DSE courses, or one DSE with one GE)*

Semester-2

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-04: Cellular signals and their decoding	3	1	0	4
DSC-05: Bioanalytical techniques	0	4	0	4
DSC-06: Classical to future innovations in Biochemistry	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-03: Infectious Disease Biology	3	1	0	4
DSE-04: Lifestyle Disorders	3	1	0	4
Generic Elective (GE) courses*				
GE-02: Enzymes and metabolic pathways	3	1	0	4
Skill enhancement course (SEC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SEC-02: Artificial Intelligence and its Applications in Biochemistry	0	2	0	2
Research Methods/ Tools/ Writing	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

* *(a student can opt for either two DSE courses, or one DSE with one GE)*

DSE

1. Developmental Biology DSE-1
2. Intermediary Metabolism DSE-2
3. Infectious Disease Biology DSE-3
4. Lifestyle Disorders DSE-4

GE

1. Enzymes and metabolic pathways GE-1
2. Food and Nutritional Biochemistry GE-2

DISCIPLINE SPECIFIC CORE COURSE – DSC-01: PROTEINS AND ENZYMES

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-01 PROTEINS AND ENZYMES	**04**	**03**		**01**	**-**	**-**

Number of weeks: 15
Number of hours: 45 (T) + 30 (P)

Learning Objectives:

The main objective of this course is to introduce basic concepts of protein structure and function, mechanism of protein folding, and methods to engineer proteins for various applications. Another objective is to offer detailed knowledge about enzymes, providing basic concepts of their mechanism of action, kinetics, regulation, inhibition, purification, and diverse applications.

Learning Outcomes:

1. Students will be able to describe levels of protein structures – their basic constituents, forces that stabilize protein structures, and their various modules and arrangements.
2. Students will be able to evaluate how proteins fold during and following translation and the consequences of improper folding.
3. Students will be able to analyse enzyme assays, kinetics, structure, regulation, mechanism of action, and reaction intermediates and inhibition.
4. Students will be able to apply this knowledge for developing novel proteins and enzymes for industrial applications.

Contents

Unit I: Amino acids: Ways of representation, Classification, Stereochemistry, Chemical and structural features, Covalent & non-covalent interactions, Importance of weak interactions in protein structures. Levels of protein structure: *Primary structure*: Flexibility and conformational restrictions, Characteristics of peptide bond, Ramachandran plot. *Secondary structure*: H- bonding scheme, Diversity in alpha-helices, Beta-stand and sheet, Turns and loops, *Supersecondary structure*: Domains and motifs. *Tertiary structure*: General properties and characteristics, Structure prediction (modeling). *Quaternary structure*: Concept of subunits and promoters and their association, Importance of quaternary structure; Various examples, Fibrous and Globular proteins, Structural Features of Membrane proteins.

12 hours

Unit II: Protein Folding and its biotechnological applications: The "protein folding problem" and problems in protein folding; Anfinsen's classical experiment; Folding curves and transitions; Models of protein folding; Assisted protein folding (Chaperones); Protein Engineering: Basic principles; Types and Methods; Strategies in protein engineering (Directed evolution, Comparative design, Rational design); Applications and case studies. Solvent Engineering: Physical basis for protein denaturation/ stability; Preferential binding and preferential hydration models; Various stabilizers and their applications.

11 hours

Unit III : Enzymology: Activation energy, Coupled reactions, Active site and its importance, Enzyme activity; Specific activity and Units; Ribozymes; Abzymes; Classification and nomenclature of enzymes. Enzyme assays: Optimization of enzyme assays. Factors influencing catalytic efficiency and the mechanisms employed. Mechanism of catalysis of various key enzymes at the molecular level. Enzyme kinetics: Significance; Rapid Equilibrium and Steady State approach, Henry- Michaelis-Menten's and Haldane equations, Significance of Km, Catalytic efficiency and turnover number; Kinetic perfection. Order of kinetics. Methods of plotting enzyme kinetics data: Lineweaver-Burk, Hanes-Woolf, Woolf-Augustinsson-Hofstee, Eadie-Scatchard; Direct linear plot; Advantages and disadvantages; Integrated form of the Henry-Michaelis-Menten equation.

11 hours

Unit IV: Enzyme Inhibition, Reversible and Irreversible inhibition, Models and types of inhibition; Kinetics and diagnostic plots related to enzyme inhibition, Dixon plots, Multisubstrate enzymes; Multisite and Allosteric enzymes; Models and examples. Regulation and control of enzyme activity: Isozymes, Zymogens, reversible covalent modification, irreversible covalent modification, Half-site reactivity; Bifunctional enzymes. Enzyme purification & Chromatography.

11 hours

Practical **30 Hours**

1. *In silico* protein sequence and structure analysis. Mining and retrieval of sequences and structures from PDB; Sequence alignment.
2. Prediction of physical and intrinsic parameters; Ramachandran Plot and its application.
3. Structure prediction and Homology modelling, Introduction to AlphaFold and other software
4. Seminal discoveries in the field of protein structure and folding, methodologies and interpretations- a discussion.

Suggested Readings:

1. C. Branden, T. Tooze. 1999. Introduction to Protein Structure (2nd Ed.), Garland Science, Taylor and Francis Group, New York, USA. ISBN: 978-0-8153-2305-1.
2. T.E. Creighton. 2002. Proteins: Structures and Molecular Properties (3rd Ed.), W.H. Freeman and Company, New York, USA. ISBN 978-0716770305.

3. R. H. Pain. 2000. Mechanisms of Protein Folding (2nd edition), Oxford University Press, Oxford, England. ISBN 978-0716770305.
4. S. Lutz, U. T. Bornscheuer. 2012. Protein Engineering Handbook, Volume-3, Wiley-VCH, Weinheim, Germany. ISBN: 978-3-527-31850-6.

Teaching Learning Process and Assessment methods

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about the significance of proteins in life; their classification; Key features of proteins that help them acquire diverse function; Properties of each of the proteinogenic amino acids along with their functional significance in protein structures; Characteristics of various physico-chemical interactions and importance of non-covalent interactions in providing proteins their shape and stability.	Outlining the history of development of knowledge about proteins through Powerpoint presentations and landmark publications; Use of stereochemical models; Question and answer sessions in the class; Amino acid characteristics will be explained using chalk and board; Two and three- dimensional pictures of the interactions in protein structures.	Structures of amino acids will be shown in ball and stick representation, and students will need to identify them along with their stereochemical identity; numerical problems relating to their pKa and pI, and how such knowledge is used in industry. A host of characteristics and features will be provided to students and they will need to match them with the type of non- covalent interactions.
II.	Students will learn about the characteristics of peptide bonds and how torsional angles are measured; Ramachandran plot and its use in validating protein structures. They will learn about the characteristics of interactions and nature of H-bonding that lead to secondary structures; Features of domains and motifs; General features of tertiary structures and arrangement of side chains; Concepts of subunits and their organization and consequences to protein structure and function	Chalk and Board for teaching the basic concepts; Power point presentations for 3D structure demonstration; Teaching module on protein structure-function (with myoglobin/ haemoglobin as a prototype), created for E- Pathshala (UGC, MHRD) will also be used.	Sequence of small sized proteins will be given and students will be asked to identify the protein and model their three-dimensional structure and predict their secondary structures. They will be assigned the task of retrieving PDB coordinates of any given protein and use the structure to plot Ramachandran maps. The domains in a given protein can be predicted and visualized along with the subunits and their interface.

III.	Importance of investigating enzyme kinetics; the important kinetic parameters like Km, Vmax, Kcat, etc.; derivation of Michaelis-Menten equation; Order of kinetics; Students will learn how to plot experimental data into various forms to calculate the various kinetic parameters and advantages and disadvantages of each such method. Students will learn how to measure fast kinetics.	The basic concepts will be explained using chalk and board; Original paper by Michaelis-Menten will be discussed. Powerpoint presentations for better representations. Student interaction in class.	Students will be asked to derive MM equation without help. Numerical problems to estimate kinetic parameters. Students will be asked to rearrange MM equation to derive the various equations which underlie each linear plot. Experimental data will be provided to plot data and derive parameters using graph papers. Students will read papers on fast kinetics and discuss about the principles in class in groups of 3.
IV	Students will learn about the various types of enzyme inhibitors; their mode of action and their influence on enzyme kinetic parameters. They will learn to plot experimental data.	Concepts will be taught using chalk and board and notes; Powerpoint presentations for images for clarity of concepts; Research papers will be provided for applications; Numerical problems will be solved.	Numerical problems on various types of inhibitors. Identification of types of inhibition from kinetic schemes and diagnostics plots

DISCIPLINE SPECIFIC CORE COURSE – DSC-02: BASIC TECHNIQUES IN BIOCHEMISTRY

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-02 BASIC TECHNIQUES IN BIOCHEMISTRY	04	-		04	-	-

Number of weeks: 15
Number of hours: 120 (P)

Learning Objectives:

- The objective of this course is to develop a clear understanding with hands-on-experience in preparing basic reagents for biochemistry experiments,
- Students will learn different methods for quantitation and characterization of biomolecules.
- The students will develop the knowledge and skills to carry out various biochemical techniques.

Learning Outcomes:

1. Students will learn about various good lab practices, working in labs and use of instruments.
2. Students will be able to make various buffers and stock solutions as well as will be able to perform protein and DNA estimation using various methods.
3. The course will provide better understanding of controls in experiments and the art of design, execution and analysis of experiments.
4. Students will be able to perform ELISA and immunoblotting and differentiate various staining and detection methods.
5. Students will also learn the method of record keeping and presentation of data.

Contents:

Unit I: Buffers: theory and practice. Preparation and storage of buffers and protein stock solutions: Concept of pH, buffers and pKa; Preparation of buffers in the laboratory over a pH range (2 to 11); Use of pH meters. Handling of buffers and storage concerns. Physiological buffers in human body.

30 Hours

Unit II: DNA and Protein quantitation and characterization: DNA and protein estimation by UV spectroscopy (denaturation and renaturation experiments), storage and concentration; Spectrophotometry, Lambert-Beer Law, Concept of extinction coefficient and λmax.

30 Hours

Unit III: Electrophoresis and Immunoblotting: Analysis of proteins - Native PAGE and SDS-PAGE for multimeric and disulfide bonded proteins, Visualization of protein bands by Coomassie staining and Silver staining, concept of sensitivity of detection. Determination of molecular weight of a protein using standards, semi-log graph plotting and interpretation, Western blot / Immunoblotting analysis of the proteins using western blot. Primary and secondary antibodies, conjugates, application of different conjugates.

30 Hours

Unit IV: ELISA- a qualitative and quantitative method for estimation of analytes, Indirect ELISA and estimation of antibody titres, sandwich ELISA for quantitation of antigen levels in samples. Applications of ELISA in diagnostics.

30 Hours

Suggested Readings:

1. J. Owen, J. Punt, S. Stranford, (2018) Kuby Immunology (8th Edition), WH Freeman and Company, USA.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. (2023) Biochemistry (10th Edition), WH Freeman and Company, USA.
3. M.R. Green and J. Sambrook (2012) Molecular cloning, A Laboratory Manual Vol. I-III. (Fourth edition) Cold Spring Harbor Laboratory Press
4. Hofmann, A., Clokie, S. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology (8th Edition), Cambridge University Press, UK.

Teaching Learning process and Assessment methods

Unit No.	Course learning outcome	Teaching and learning activity	Assessment task
Unit I	Students will understand the fundamental concepts of pH, pKa, and buffer systems. They will develop practical skills in preparing buffers across a pH range and using pH meters efficiently.	Interactive lectures on buffer theory, hands-on laboratory sessions for buffer preparation, and demonstrations on pH meter calibration and troubleshooting. Discussions on real-	Mid-term and end-term tests on buffer calculations and concepts. Practical assessments on buffer preparation and pH measurement. Submission of lab

	Additionally, they will gain expertise in handling and storing buffers to maintain their stability.	world applications of buffers in biochemical processes.	reports on buffer stability and handling techniques.
Unit II	Students will gain knowledge of different techniques for estimating DNA and protein concentrations using UV spectroscopy. They will learn about protein storage and concentration techniques. Additionally, they will understand the spectroscopic characterization of proteins and protein stability analysis.	Lectures on the principles of UV spectroscopy, extinction coefficients, and protein quantification methods. Laboratory demonstrations on DNA and protein estimation techniques. Hands-on sessions on protein handling and storage.	Mid-term and end-term tests on UV spectroscopy principles. Practical assessments on DNA and protein estimation. Lab reports on protein quantification and stability measurements.
Unit III	Students will develop expertise in analysing proteins using electrophoretic techniques such as Native PAGE and SDS-PAGE. They will learn methods for visualizing proteins using Coomassie and Silver staining. Additionally, they will gain knowledge of molecular weight determination and Western blot analysis.	Lectures on electrophoretic separation principles and gel composition. Hands-on training in sample preparation, gel running, and staining techniques. Demonstrations on Western blot transfer and antibody-based detection.	Practical assessments on gel electrophoresis and staining techniques. Mid-term and end-term tests on electrophoresis principles and interpretation of results. Submission of lab reports on protein analysis and Western blotting.
Unit IV	Students will understand the principles of ELISA for qualitative and quantitative detection of biomolecules. They will gain expertise in performing indirect and sandwich ELISA for antibody and antigen quantification. They will also explore the clinical and research applications of ELISA.	Lectures on ELISA principles and types. Hands-on sessions on indirect and sandwich ELISA techniques. Data analysis workshops on interpreting ELISA results.	Mid-term and end-term tests on ELISA principles and applications. Practical assessments on ELISA procedures and data interpretation. Submission of lab reports on antibody titre estimation and antigen quantification.

DISCIPLINE SPECIFIC CORE COURSE – DSC-03: EMERGING AREAS IN BIOCHEMISTRY

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-03 EMERGING AREAS IN BIOCHEMISTRY	**04**	**03**		**01**	-	**-**

Number of weeks: 15
Number of hours: 45 (T) + 30 (P)

Learning Objectives:

The course intends to inculcate the skills in students to explore an important and current scientific topic and present collated information that reflects their understanding of the topic.

Learning Outcomes:

1. Upon successful completion of the course, students will learn how to survey scientific literature, screen relevant information, apply their knowledge of biochemistry to understand research findings and analyse the results reported in literature.
2. Students will learn how to collate scientific findings and prepare a scientific document on the analysis.
3. Students will learn how to prepare bibliography in scientific text, check for plagiarism and be aware of the softwares to avoid plagiarism.
4. Students will learn to present their results orally and in written form.

Contents:

Unit I: Emerging areas relevant to human health and biochemistry, assignment of a particular area, use of online search engines and scientific websites to survey available literature on the area / topic assigned. In-depth study of review and research activities to understand the current state of work in the particular area.

16 hours

Unit II: Identify and understand basic concepts, techniques, methodologies employed in the area of research through published literature, analyse the results obtained and identify key achievement and findings, identify gap areas for further research.

12 hour

Unit III: Compilation of the analysis into a detailed oral presentation. Incorporation of background information, current status in the area, detailed explanation of the research articles, experimental findings, area and scope of further work.

8 hours

Unit IV: Preparation of a scientific document on the analysis, introduction to appropriate softwares for referring and plagiarism and their use for the preparation of the document.

9 hours

Practical: **30 hours**

1. Designing slide decks to enhance the quality of scientific presentations
2. How to use and add animations, graphics and flowcharts in presentations
3. How to deliver scientific presentations in a clear and engaging manner
4. Use of narrative techniques to communicate research
5. Drafting scientific document and use of bibliographic software.

Suggested Readings:

1. Review articles in scientific journals.
2. Research articles in scientific journals.
3. Standard textbooks of Biochemistry as appropriate.

Teaching Learning process and Assessment methods

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will know how to search for research papers using combination of key words; They will learn how to download references and save them in appropriate softwares like EndNote; Students will learn to differentiate review articles from research articles; Students will learn how to make Powerpoint presentation file.	A Powerpoint presentation on the art of presentation will be utilized initially to train students; Interactions with students will be conducted to answer their queries.	Topic on current and important research areas will be assigned individually to students and they will be asked to retrieve literature and show them to teachers for verification. They will be shown review and research articles and asked to identify them. They will be motivated to make short presentations as journal club seminars for the practice of oration.

II	Students will learn how to analyse and interpret research findings. They will also learn to identify research gap areas.	Teachers will assist the students in understanding the experiments and analyse the research findings in published literature.	Students will be assessed for their understanding of research findings in the presentation.
III	The students will learn how to make presentations in public and will also learn to answer questions related to their presentation.	Previous presentations by students will be shown. Interactions on how to deliver seminars and answer the questions will be conducted	Students will be evaluated for their presenting skills and handling of questions at the end of the semester. Questions will be asked based on the topics presented and the students will be assessed based on their performance.
IV	Students will learn how to prepare a write-up to summarize their understanding of a research topic; They will have advanced learning or MS Word, MS Excel and other softwares. They will learn how to cite references in text and how to organize them in a bibliographic section either manually or using softwares like EndNote. Students will learn about the softwares for plagiarism and how to use them.	Teachers will describe how to prepare write-up and what are the points to keep in mind while doing so. Student queries will be entertained by teachers. They will be shown previous term papers for better understanding. Students will be informed about the issues related plagiarism.	Students will need to write term paper on the topic assigned. If needed, they will be asked to write short essays on simpler topics for practice of writing. Department also often organizes essay writing competition to allow students the opportunity to improve their writing. They will be asked to run their write-up through plagiarism software and show the outcome to teachers.

DISCIPLINE SPECIFIC CORE COURSE – DSC-04: CELLULAR SIGNALS AND THEIR DECODING

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-04 CELLULAR SIGNALS AND THEIR DECODING	04	03		01	-	-

Number of weeks: 15
Number of hours: 45 (T) + 30 (P)

Learning Objectives:

The objective is to offer detailed knowledge about various cellular signals and the processes through which these signals are decoded, various signal transduction pathways associated with the cellular processes of the cells. The course also aims to provide insights into how classical cellular pathways were experimentally discovered.

Learning Outcomes:

1. Students will acquire insights into transport processes across cell membranes, process of endocytosis and protein sorting/translocation to various organelles.
2. Students will gain knowledge about the concepts of various cellular signal transduction pathways
3. Students will acquire insights into the mechanisms of cellular responses under varying conditions
4. Students will learn the association of the defects in the signalling processes to various diseases.

Contents:

Unit I: Role of signal sequences in protein sorting and localisation: Historical background, Protein translocation across ER- signal sequence and SRP. Co-translational and post-translational translocation into ER. Signals for insertion of proteins into ER membrane - positive-inside rule, protein modification (glycosylation and GPI anchor) and quality control of protein and UPR in ER. Retrograde signals and pathways, Golgi vesicular traffic, protein import in mitochondria, peroxisomes, chloroplasts. Signal for Import and Export of

Macromolecules from Nucleus. Glycosylation in mammalian cells, origin, nature and types of Glycosylation. Role of Glycosylation in protein stability and folding with reference to ER exit. Introduction to post-translational modifications.

12 hours

Unit II: Short Term and Long-Term Cellular Signalling: General principles of signalling by cell surface receptors, endocrine, paracrine and autocrine signalling. Components of intracellular signal-transduction pathways. G- protein coupled receptor system, General mechanism of the activation of effector molecules associated with GPCRs, GPCRs that activate or inhibit adenylate cyclase, activate phospholipase C, or that regulate ion channels. Receptor tyrosine kinases - their discovery, signalling of growth factors (EGF and Insulin) via activation of receptor tyrosine kinases. Non-receptor tyrosine kinases, Nuclear receptor superfamily, signalling responses by NO, peptide hormones, eicosanoids and brief introduction to plant hormones.

11 hours

Unit III: Types of signalling pathways: MAP kinase pathway, role of Ras oncogene, cytokine signalling via JAK/STAT pathway, signalling of TGFβ by direct activating Smad proteins, NF-kB pathway, cAMP pathway and PKA signalling (fight and flight response), cGMP pathway, role of phospholipids and calcium signalling, PI3 kinase and AKT pathway, Hedgehog, Wnt and Notch signalling pathways. Two-component systems. Signaling pathway involved in exocytosis (insulin secretion as an example).

11 hours

Unit IV: Cell cycle, Cell Survival and Death Signal: Cell cycle and regulation, Restriction point of cell cycle and Quiescent cells. Control of cell cycle in yeast and mammalian cells. Role of various cycle-CDK complexes in the transition of various checkpoint of cell cycle. Role of ubiquitin-protein ligase –SCF and APC/C in the control of cell cycle. Cytokinesis. Programmed cell death and role of Caspase protein in apoptosis. Various pro-apoptotic and anti-apoptotic regulators and pathways. Autophagy and its mechanisms. Ferroptosis.

11 hours

Practicals: **30 hours**

1. Case studies to discuss the importance of signalling processes in various diseases
2. Video demonstrations on cellular architecture, transport mechanisms
3. Assays to distinguish apoptotic cells from normal and necrotic cells
4. The role of checkpoints as therapy targets in cancer management

Suggested readings

1. H. Lodish, A. Berk, C.A. Kaiser, M. Kreiger, M. P. Scott, A. Bretscher, H. Ploegh, P. Matsudaria. 2021. Molecular Cell Biology, 9th edition, W.H. Freeman and Company, New York., USA.
2. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P Walter. 2020. Molecular Biology of the Cell 7th edition, Garland Publishing, Inc. New York. USA.
3. G.M. Cooper. 2023. The Cell: Molecular Approach 9th edition, ASM Press, Washington, D.C. USA.

4. L. Harvey, B. Arnold, Z.S. Lawrence, M. Paul, D. Baltimore, J.E. Darnell. 2021. Molecular Cell Biology 9th edition, W. H. Freeman & Co, New York, USA.

Teaching Learning process and Assessment methods

Unit No.	Course learning outcome	Teaching and learning activity	Assessment task
Unit I	Students will gain knowledge about the process of protein sorting, role of ER in quality control and various post-translational modifications.	Board and powerpoint teaching methods will be employed for taking the lectures. Classes will be held in an interactive mode. Students will be encouraged to ask questions and have discussions on the topics taught.	Mid-term internal assessment test will be conducted. Regular class revisions and oral questions will be asked on the previously taught questions.
Unit II	Students will gain knowledge about the concepts of various cellular signal transduction pathways – about the types of receptors and intracellular messengers	Board and powerpoint teaching methods will be employed for taking the lectures. Classes will be held in an interactive mode. Students will be encouraged to ask questions and have discussions on the topics taught.	Mid-term internal assessment test will be conducted. Students will be asked to prepare and Present research/ review articles related on various topics assigned to them.
Unit III	Students will acquire insight into the mechanisms of cellular responses under varying conditions. Students will learn the association of the defects in the signaling processes to various diseases	Board and powerpoint teaching methods will be employed for taking the lectures. Scientific research articles will be discussed in the class. Students will be encouraged to ask questions and have discussions on the topics taught.	End-term internal assessment test will be conducted. Regular class revisions and oral questions will be asked on the previously taught questions.
Unit IV	Students will be able to learn about the concepts of cell cycle, apoptosis and autophagy. They will also learn about the role of these processes in cancer and other diseases.	Board and powerpoint teaching methods will be employed for taking the lectures. Scientific research articles will be discussed in the class. Students will be encouraged to ask questions and have discussions on the topics taught.	End-term internal assessment test will be conducted. Regular class revisions and oral questions will be asked on the previously taught questions.

DISCIPLINE SPECIFIC CORE COURSE – DSC-05: BIOANALYTICAL TECHNIQUES

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-05 BIOANALYTICAL TECHNIQUES	04		-	04	-	-

Number of weeks: 15
Number of hours: 120 (P)

Learning Objectives:

The objective of this course is to provide in depth knowledge with hands-on-experience in bacterial cell culture, immuno-techniques, animal cell culture, cloning, gene expression in *E. coli,* protein purification, enzyme kinetics and bioinformatics.

Learning Outcomes:

1. Students will get hands-on training for bacterial cell culture, molecular biology techniques, gene cloning and protein purification.
2. Students will obtain hands-on training for animal cell culture, transfection of foreign genes and their expression analysis.
3. The course will provide better understanding of controls in experiments and the art of design, execution and analysis of experiments.
4. Students will learn the tools to analyse DNA and protein sequences.

Contents

Unit I: Growth of Bacterial culture, preparation and sterilization of growth medium, Streaking of culture and inoculation, Competent cell preparation and Transformation. Plasmid DNA isolation, amplification of gene by PCR, insertion of gene into expression vector to produce recombinant protein (Isolation of Vector, Restriction digestion, extraction of DNA from gel, Ligation, Transformation). Screening of positive clones by colony PCR and restriction digestion analysis.

30 hours

Unit II: Expression, localization and purification of recombinant protein. Various methods to optimize expression, techniques to improve the solubility of the recombinant protein, protein purification by chromatographic methods. Measurement of kinetic parameters and factors influencing enzyme activity.

35 hours

Unit III: Introduction to animal tissue culture, media compositions and learning about aseptic conditions. Growing mammalian cells, trypsinization, plating, cryofreezing and general maintenance of cells. Harvesting of cells and counting using Hemocytometer; Investigation of the effect of various harsh conditions on cell viability using Trypan blue. Preparation of transfection-grade plasmid DNA using commercial columns, analysis of its quality and yield, Transfection of plasmids into mammalian cells. Visualization of the fluorescent proteins in live cells and calculation of transfection efficiency. Assessment of localization (nuclear or cytoplasm) and co-localization of the proteins. Preparation of transfected cell lysates and Western Blot analysis of the overexpressed proteins.

40 hours

Unit IV: Pairwise alignment to identify homologous sequences and interpret alignment scores. Multiple sequence alignment (MSA) using Clustal Omega, MUSCLE, and MAFFT to analyze alignment quality and conserved regions. Phylogenetic analysis using MEGA, PhyML, and FastTree, comparing different tree-building methods such as Neighbor-Joining and Maximum Likelihood. Web-based phylogenetic analysis using Phylogeny.fr and MEGA for constructing and interpreting evolutionary relationships. Sequence editing and visualization using BioEdit, AliView, and Geneious for sequence preparation and alignment evaluation.

15 hours

Suggested Readings:

1. D.L. Nelson, M.M. Cox. (2021). Lehninger Principles of Biochemistry (8th Edition), W.H. Freeman and Company, New York, USA.
2. M.R. Green and J. Sambrook (2012) Molecular cloning, A Laboratory Manual Vol. I-III. (Fourth edition) Cold Spring Harbor Laboratory Press.
3. Fred M. Ausubel *et al.* editors (2017) Current Protocols in Molecular Biology. John Wiley and Sons, Inc.
4. John E. Coligan *et al.* editors (2017) Current Protocols in Protein Science. John Wiley and Sons, Inc.
5. T.A. Brown. (2020) Gene Cloning and DNA Analysis. (8th Edition). Wiley-Blackwell publishing (Oxford, UK).
6. L. Wolpert, R. Beddington, T. Jessell. 2019. Principles of Development (6th Edition), Oxford University Press, New York, USA.

Teaching Learning process and Assessment methods

Unit No.	Course learning outcome	Teaching and learning activity	Assessment task
Unit I	Students will be able to do bacterial culturing, DNA isolation, restriction digestion and cloning of genes.	Students will be provided individual hands-on –training along with extensive theory classes for understanding the concepts. They will be taught various ways to clone a foreign gene, its various applications and	Students will be given assignment tasks related to gene cloning and PCR amplification, to design primers *in silico* and to devise

		troubleshooting. They will learn to make competent cells and perform gene cloning in an *E.coli* expression vector.	new cloning strategies.
Unit II	Students will be able to perform protein expression and purification and will learn how to troubleshoot the problems.	Extensive theory classes and discussion on protein expression and purification. Hands-on-training to pack purification columns. Various optimization techniques will be taught for achieving better expression and solubility of proteins. Enzyme assays will be carried out under different conditions.	Discussions on the concepts of purification and the enzymatic assays will be carried out, students will be asked oral questions and quizzes will be conducted for the assessment of their concepts of enzyme inhibition.
Unit III	Students will learn to perform tissue culturing, transfection of mammalian cell lines, expression of proteins in cell lines and immunoblotting.	Chalk and Board teaching, discussion of lab practices, basic concepts of cell culturing, plasmid isolation, transfection. Live demonstration of DNA precipitate preparation will be given, various methods of introducing DNA into cells will be discussed using powerpoint presentation and consultation of scientific articles.	Students will be asked oral questions related to cell culture techniques and general GLPs. Group discussion, debates, solving analytical questions, quiz etc. Students will be encouraged to read research articles related to the practicals and discuss the findings. Solving of practical based analytical questions, discussion of situations in research, quiz, students will be asked to prepare short presentations on the practicals performed and discuss their findings.
Unit IV	Students will get hands on experience of using various bioinformatics tools that will be useful in drug discovery, big data analysis etc.	Computational hands-on training will be provided to the students so that they will be able to employ the bioinformatics tools for research applications and scripting will be taught through power-point presentation.	For the assessment of their bioinformatics knowledge, the students will be given tests and assignments tasks to analyse data and perform simple computational tasks.

DISCIPLINE SPECIFIC CORE COURSE – DSC-06: CLASSICAL TO FUTURE INNOVATIONS IN BIOCHEMISTRY

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-06 CLASSICAL TO FUTURE INNOVATIONS IN BIOCHEMISTRY	**04**	**03**		**01**	-	-

Number of weeks: 15
Number of hours: 45 (T) + 30 (P)

Learning Objectives:

The course intends to engage in an independent, active and self-driven learning method and to inculcate the skills in students to explore important classical and future innovations and present collated information that reflects understanding of the topic.

Learning Outcomes:

1. Students will learn about the history of scientific landmarks and classical discoveries.
2. Students will learn about various techniques that have impacted progress of science.
3. Students will learn to carry out survey on a particular area and topic.
4. Students will imbibe the skills of preparation of scientific presentations and documents.

Contents:

Unit I: Historical perspective on the landmark developments in science, their impact on the present-day science, major breakthrough discoveries of biological processes, survey of seminal research articles in the literature.

10 hours

Unit II: Innovations that led to development of tools and techniques in cell biology, immunology, molecular biology and recombinant DNA technology, and allied areas, the impact of these techniques on progress of scientific understanding, evolution of these techniques with time.

12 hours

Unit III: Integration of scientific knowledge, tools and techniques to address a particular area and problem related to human health, study of available literature on the specific problem, experimental strategies to address the problem, major results and key findings, gap areas, limitations and future scope to address fundamental questions in the area to devise interventions.

12 hours

Unit IV: Compilation of the information into a detailed presentation, documentation of the information in a scientific manner using appropriate tools, relevance of statistical tools in research and data presentation.

11 hours

Practical: **30 hours**

1. Group discussions for classical Nobel prize discoveries/innovations and understanding the research studies and findings
2. Group discussions and assignments to identify research gap areas in the relevant and emerging areas.
3. Group discussion on plagiarism – definition, types, use of plagiarism detection tools with an emphasis on ethical integrity in science.

Suggested Readings:

1. Review articles in scientific journals.
2. Research articles in scientific journals.
3. Standard textbooks of Biochemistry as appropriate.
4. Nobel prize website
5. Books by Nobel laureates

Teaching Learning process and Assessment methods

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will get aware of some of the classical innovations and seminal discoveries from the literature.	Students will be taught how to access the articles by using the online tools and journal websites.	Students will be assigned topics on important innovations and discoveries and they will be asked to retrieve literature and select relevant articles which will be assessed for their suitability for the presentation by the teachers. They will be motivated to make short presentations as journal club seminars for practice of oration.

II	Students will learn the skill of reading review and research articles, how to understand the background of a particular study, identify the gap areas and how to plan a particular study to address the problem and also how to interpret research findings.	Teachers will assist the students in understanding various selected articles and the experiments employed to address the research gap and in the analysis of the results	Students will be assessed for their understanding of research findings in the presentation.
III	The students will learn how to make presentations in public and will also learn to answer questions related to their presentation.	Previous presentations by students will be shown. Interactions on how to deliver seminars and answer the questions will be conducted	Students will be evaluated for their presenting skills and handling of questions at the end of the semester. Questions will be asked based on the topics presented and the students will be assessed based on their performance.
IV	Students will learn how to prepare a scientific academic document to summarize their understanding of a research topic.	Teachers will describe how to prepare a scientific document and what are the points to keep in mind while doing so. Students will be informed about the issues related plagiarism. Various bibliography tools will also be introduced to the students.	Students will need to write term paper on the topic assigned. The assessment will be based on the quality and completeness of the scientific document submitted by the students.

DISCIPLINE SPECIFIC ELECTIVE COURSE : DSE-01
DEVELOPMENTAL 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		
DSE-01 DEVELOPMENTAL BIOLOGY	04	03		01	B.Sc. in any area of Life Sciences	-

Number of weeks: 15
Number of hours: 45 (T) + 30 (P)

Learning Objectives:

This course aims to provide a comprehensive understanding of Developmental Biology, covering fundamental principles, molecular mechanisms, model systems and their applications in research, medical implications of developmental biology in understanding disorders and treatment of various human diseases.

Learning Outcomes:

1. Students will acquire knowledge about fundamental developmental processes, explain key principles of embryogenesis, cell fate determination, germ layer formation, and morphogenesis, linking developmental mechanisms to evolutionary changes.
2. Students will be able to describe the role of signaling pathways, cell-cell communication, and gene regulation in developmental processes, including Nieuwkoop center, Spemann-Mangold organizer, and EMT etc.
3. Students will be able to evaluate contributions of various model systems in studying pattern formation, organogenesis, and gene function in developmental biology and understanding various development associated defects.
4. Students will learn about the significance of stem cells, regenerative medicine, and therapeutic cloning in treating developmental disorders and designing future medical therapies. Case studies and discussions will foster critical thinking and research aptitude.

Contents

Unit I: Fundamentals of Developmental Biology and Early Developmental Processes: History and basic concepts of developmental processes, mechanisms of specifying cell fate, role of development in evolutionary change, early events of fertilization, implantation, generation of multicellular embryo, formation of germ layers, patterning of vertebrate body plan, morphogenesis including cell adhesion, cleavage, blastula formation, gastrulation, neural tube formation, and cell migration.

10 hours

Unit II: Molecular Events in Development and Signaling Pathways: Molecular events of embryogenesis: Nieuwkoop center, Spemann-Mangold organizer theory, mesodermal induction, role of cell-cell communication in development, concepts of induction and competence, epithelial-mesenchymal interactions, developmental signals from the extracellular matrix, and roles of various signaling pathways during development.

10 hours

Unit III: Model Systems in Development: Model organisms and their contributions to developmental biology: *C. elegans* (cell lineage, cell fate determination, regulation of blastomere identity, body axis formation, organogenesis), Drosophila (maternal and zygotic genes, polarity determination, pattern formation, segmentation, homeotic genes), Zebrafish (developmental stages, somite formation, pigment patterning), Mouse (vertebrate development, gene function studies with knockout/knock-in models, generation of disease models), Arabidopsis (life cycle, phytohormones, embryogenesis, flowering, ABC model, homeotic genes, MADS-box, shoot-root development, genetic control of floral modifications and organ patterning). Transgenics and their applications.

15 hours

Unit IV: Role of Stem Cells in Development and Medical Implications of Developmental Biology: Classification and properties of stem cells, adult and embryonic stem cells, cancer stem cells, stem cell markers, applications of stem cells, advancements in research, and associated ethical issues. Developmental disorders, in-vitro fertilization, gene therapy, therapeutic cloning, iPS technology and regeneration therapy, and design of future medicines leveraging developmental biology concepts.

10 hours

Practical: **30 hours**

1. Observation of embryogenesis stages in model organisms such as Drosophila, Zebrafish, and *C. elegans*,
2. Analysis of cell adhesion, cleavage, gastrulation, somite formation through microscopy. Learning techniques of stem cell culture and differentiation techniques, 3D culture, tissue engineering and 3D printing.
3. Case studies on developmental disorders, and review of research articles based on various model systems and developmental pathways.

Suggested readings:

1. S. F. Gilbert. 2018. Developmental Biology (11th Edition), Sinauer Associates, Inc., MA, USA.
2. D.L. Riddle, T. Blumenthal, B.J. Meyer, J.R. Priess. 1997. C. elegans II. Cold Spring Harbor Laboratory Press, New York, USA.
3. Worm Book: The Online Review of C. elegans Biology. 2005. The C. elegans Research Community, Pasadena, USA. (www.wormbook.org)
4. L. Wolpert, R. Beddington, T. Jessell. 2010. Principles of Development (4th Edition), Oxford University Press, New York, USA.
5. P. Matsudaira. 2003. Molecular Cell Biology, W.H. Freeman, New York, USA. Nagy, M. Gertsenstein, K Vintersten, R. Behringer. 2003. Manipulating the mouse embryo: a laboratory manual, Cold spring Harbor Press, New York, USA.

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about basic concepts of developmental processes, how cell fate is determined and link between development evolution. Role of various signaling pathways will be learnt, early events of fertilization, implantation, germ layer formation and patterning of vertebrate body plan.	Chalk and board and power point presentations, regular question-answer activities, consultation of relevant research articles and watching videos.	Assessment through interactive discussion in the class, periodic question-answer sessions during teaching. Oral questions will be asked, students will be given to solve analytical problems relating to class teachings. Students will be asked to read original research articles and discuss the experimental approach and findings.
II.	Students will learn the molecular events of embryogenesis: Nieuwkoop center, Spemann organizer theory, mesodermal induction and cell movements during gastrulation.	Chalk and board and Power point presentations, regular question-answer activities, consultation of relevant research articles, reviews and watching videos.	Writing assignments given to students, schematics of various molecular events will be shown with missing links, students will fill in the names of the missing molecules. Other activities like quiz, puzzles etc. will be held in class. Students will be asked to read relevant research papers and discuss the results in class.
III	Students will learn about utility of various model organisms to follow development processes and development of various disease models. Students will learn how to elucidate the development related signaling mechanisms.	Chalk and board and Power point presentations, regular question-answer activities, consultation of relevant research articles and reviews.	Pictures of various mutants will be shown for students to identify the developmental defects, oral questions, quiz and puzzles will be used for day to day evaluation during class. Reading of research papers related to various model organisms and discussion.
IV	Properties and significance of stem cells and their role in development will be learnt. They will understand their research applications and current research status in India. Students will learn about developmental disorders, *in-vitro* fertilization, therapeutic cloning, iPS and regenerative medicine.	Chalk and board and Power point presentations, regular interaction activities, discussion of case studies.	Students will be asked to segregate different type of stem of cells based on the markers, they will be asked design experiments to test stemness properties of cells in animal models. Students will be evaluated through class discussion, assignments and tests.

DISCIPLINE SPECIFIC ELECTIVE COURSE : DSE-02
INTERMEDIARY METABOLISM

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		
DSE-02 INTERMEDIARY METABOLISM	**04**	**03**		**01**	**B.Sc. in any area of Life Sciences**	**-**

Number of weeks: 15

Number of hours: 45 (T) + 30 (P)

Learning Objectives:

The objective is to offer detailed and comprehensive knowledge about the synthesis and catabolism of biomolecules such as carbohydrates, lipids, amino acids and nucleotides. The regulation of the metabolic processes as well as the disease correlation of the metabolic disorders will also be taught.

Learning Outcomes:

1. Students will learn about various kinds of biomolecules and their physiological role.
2. Students will gain insights into the detailed synthesis and breakdown of the various biomolecules
3. Students will gain knowledge about various metabolic disorders that will help them to know the importance of various biomolecules in terms of disease correlation.
4. Students will learn about the integration of various metabolic pathways and their cross-talk.

Contents

Unit I: Carbohydrate metabolism. Overview of metabolism and metabolic reactions, catabolism, anabolism, ATP as energy currency of the cell, reducing power of the cell. Anaerobic production of ATP, Glycolysis, Fermentation, Regulation, Utilization of sugars other than glucose. Gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis, pentose phosphate pathway, glucuronic acid pathway. Aerobic production of ATP, TCA cycle, regulation. Glycogenesis and glycogenolysis, regulation of glycogen metabolism, Signalling pathways, Hormonal regulation of carbohydrate metabolism, molecular aspects of diseases caused by dysregulation of metabolic pathways.

12 hours

Unit II: Lipid Metabolism. Absorption, transport and storage of lipids and TAGs, Lipid metabolism and regulation, Biosynthesis and degradation of TAGs and phospholipids, fatty acid oxidation, ketone bodies metabolism, ketoacidosis, cholesterol metabolism, Molecular mechanism of steroid and lipoprotein metabolism.

11 hours

Unit III: Amino Acids and Nucleotide Metabolism. Role of essential and non-essential amino acids in growth and development. Protein calorie malnutrition - Kwashiorkor and Marasmus, catabolism of amino acids. Glucogenic and ketogenic amino acids. Disorders of amino acids metabolism, biosynthesis of urea, its regulation and urea cycle disorders, overview of amino acid synthesis, Biosynthesis of non-essential amino acids and its regulation, precursor functions of amino acids and its importance, De novo synthesis and breakdown of purine and pyrimidine nucleotides, regulation and salvage pathways, Digestion of nucleic acids, Inhibitors of nucleotide metabolism.

11 hours

Unit IV: Integration of metabolic pathways, tissue specific metabolism (brain, muscle, and liver). Molecular mechanisms and regulation of carbohydrate, lipid, amino acids and nucleotide metabolism.

11 hours

Practicals: **30 hours**

1. Case studies for various metabolic disorders - diseases caused by abnormal metabolic pathways, glycogen storage diseases, inborn errors of metabolism, disorders of nucleotide metabolism
2. Group discussion on importance of metabolites in disease diagnosis and development of various diagnostic methods
3. Case studies for analysis of blood reports and disease diagnosis.

Suggested readings

1. Lehninger: Principles of Biochemistry (2021) 8th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1- 4641-0962-1
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4 / BRV ISBN: 978-0-470-60152-
3. Biochemistry (2023) 10th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4.
4. Harper's Biochemistry (2022) 32nd ed., Murray, R.K., Granner, D.K., Mayes and P.A., Rodwell, V.W., Lange Medical Books/McGraw Hill. ISBN:978-0-07-176-576-3.

Teaching Learning process and Assessment methods

Unit No.	Course learning outcome	Teaching and learning activity	Assessment task
Unit I	Students will gain insights into the detailed synthesis and breakdown of the carbohydrates and the metabolic disorders associated with these pathways	Board and powerpoint teaching methods will be employed for taking the lectures. Classes will be held in an interactive mode. Students will be encouraged to ask questions and have discussions on the topics taught.	Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics.
Unit II	Students will gain insights into the detailed synthesis and breakdown of the lipids and the metabolic disorders associated with these pathways	Board and powerpoint teaching methods will be employed for taking the lectures. Classes will be held in an interactive mode. Students will be encouraged to ask questions and have discussions on the topics taught.	Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics.
Unit III	Students will gain insights into the detailed synthesis and breakdown of the amino acids and nucleotides and the metabolic disorders associated with these pathways	Board and powerpoint teaching methods will be employed for taking the lectures. Classes will be held in an interactive mode. Students will be encouraged to ask questions and have discussions on the topics taught.	Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics.
Unit IV	Students will learn about the integration of various metabolic pathways and their cross-talk	Board and powerpoint teaching methods will be employed for taking the lectures. Classes will be held in an interactive mode. Students will be encouraged to ask questions and have discussions on the topics taught.	Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics.

DISCIPLINE SPECIFIC ELECTIVE COURSE : DSE-03
INFECTIOUS DISEASE 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		
DSE-03 INFECTIOUS DISEASE BIOLOGY	04	03		01	B.Sc. in any area of Life Sciences	-

Number of weeks: 15
Number of hours: 45 (T) + 30 (P)

Learning Objectives:

The objective is to offer detailed knowledge about the mechanisms of various human infectious diseases, their cause, transmission, detection, treatment and prevention.

Learning Outcomes:

1. Students will gain overall knowledge about the mechanisms of disease cause, transmission, detection, treatment and prevention.
2. The learning gained about development of various intervention strategies such as diagnostics, therapeutics and vaccines will enable them to apply this knowledge later to infection disease research.
3. Students will develop the ability to relate to any existing or emerging infection as well as will learn about drug resistance and its mechanisms. The students will have the know-how to research and develop new tools for their management.

Contents:

Unit I: Overview of infectious diseases, infectious agents - Bacteria, Viruses, protozoa and fungi; pathogenicity and virulence; Facultative/obligate intracellular pathogens. Concepts of epidemiology, disease transmission, management of disease spread and control. Drug discovery and drug resistance, vaccine development, clinical trials. ONE HEALTH approach - associated diseases, pathogens along with introduction to zoonotic diseases.

12 hours

Unit II: Bacterial diseases, epidemiology, transmission, signs and symptoms, causative agent, history, infection and pathogenesis, disease management, intervention strategies: diagnostics, Therapeutics and vaccines for Tuberculosis, Typhoid, Cholera. Drug resistance, mechanisms, Multidrug efflux pumps, extended spectrum β-lactamases (ESBL) and implications on public health. WHO Bacterial Priority Pathogens List in context to the impact on AMR.

11 hours

Unit III: Viral diseases, epidemiology, transmission, signs and symptoms, causative agent, history, infection and pathogenesis, disease management, Detection, Drugs and inhibitors, Vaccines, molecular mechanisms for AIDS, hepatitis, influenza, dengue, polio, herpes, MRSA, SARS virus, Bird flu, prions, AIDS, Dengue Hemorrhagic Fever. Emerging and re-emerging infectious diseases and evolution of viral diseases.

11 hours

Unit IV: The cell structure of *Leishmania*, Life cycle, Types of leishmaniasis, epidemiology, disease management, Diagnosis, and treatment for visceral and cutaneous leishmaniasis, Mechanism of drug resistance, and drug susceptibility for promastigotes and amastigotes. The cellular structure of *Plasmodium*, the life cycle of *Plasmodium*, factors affecting Transmission of the parasite asymptomatic malaria, Drug-resistant parasites and Vaccine development, identification of new drug targets. The cellular structure of *Entamoeba histolytica*, Life cycle, Mode of transmission, The cellular structure of *Trypanosoma brucei* and *Trypanosoma cruzi*, Life cycle, Trypanosomiasis.

11 hours

Practicals: **30 hours**

1. Case studies for disease diagnostics
2. Pandemic preparedness and emergency responses
3. Group discussion on biosafety levels, recognizing the biosafety levels, case studies on risk assessment and biosecurity events

Suggested readings

1. Principles and practices of Infectious diseases, 7th edition, Mandell, Douglas and Bennett. S, Volume, 2. Churchill Livingstone Elsevier. ISBN: 978-0-443-06839-3
2. Sherris Medical Microbiology: An Introduction to Infectious Diseases, 8th edition. (2021). Kenneth J. Ryan, C. George Ray, Publisher: McGraw-Hill. ISBN-13: 978-0071604024 ISBN-10: 0071604022
3. Medical Microbiology. 9th edition (2020). Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller, Elsevier Health Sciences. ISBN: 978-0-323-08692-9.
4. System Vaccinology: The History, the Translational Challenges and the Future; by Vijay Kumar Prajapati, Elsevier, ISBN: 9780323859417
5. Bacterial Pathogenesis: A molecular approach by Salyers AA and Whitt DD eds. American Society for Microbiology Press, Washington, DC USA. 2002

Teaching Learning process and Assessment methods

Unit No.	Course learning outcome	Teaching and learning activity	Assessment task
Unit I	Students will gain overall knowledge about the mechanisms of disease cause, transmission,	Board and PowerPoint teaching methods will be employed for taking the lectures. Classes will be	Internal assessment tests (mid-term and end-term) will be

	detection, treatment and prevention, various intervention strategies, disease management. Students will also gain insights into the concept of ONE HEALTH and zoonotic diseases	held in an interactive mode. Students will be encouraged to ask questions and have discussions on the topics taught.	conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics.
Unit II	Students will learn about various bacterial diseases, their molecular mechanisms and intervention strategies.	Board and powerpoint teaching methods will be employed for taking the lectures. Classes will be held in an interactive mode. Students will be encouraged to ask questions and have discussions on the topics taught.	Internal assessment tests (mid- term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics.
Unit III	Students will learn about various viral diseases, their molecular mechanisms and intervention strategies.	Board and powerpoint teaching methods will be employed for taking the lectures. Classes will be held in an interactive mode. Students will be encouraged to ask questions and have discussions on the topics taught.	Internal assessment tests (mid- term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics.
Unit IV	Students will learn about various parasitic diseases, their molecular mechanisms and intervention strategies.	Board and powerpoint teaching methods will be employed for taking the lectures. Classes will be held in an interactive mode. Students will be encouraged to ask questions and have discussions on the topics taught.	Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics.

DISCIPLINE SPECIFIC ELECTIVE COURSE: DSE-04
LIFESTYLE DISORDERS

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		
DSE-04 LIFESTYLE DISORDERS	**04**	**03**		**01**	**B.Sc. in any area of Life Sciences**	**-**

Number of weeks: 15
Number of hours: 45 (T) + 30 (P)

Learning Objectives

The aim of the course is to provide a broad understanding of lifestyle-associated disorders, including obesity, diabetes, cardiovascular diseases (CVDs), COPD, and cancer, as well as their diagnosis and interventions. This course will also prepare students for careers in healthcare and biomedical research.

Learning Outcomes

1. Gain knowledge of major lifestyle disorders, their causes, symptoms, and management.
2. Understand the molecular basis and treatment strategies for cancer, CVDs, obesity, and diabetes.
3. Learn diagnostic tools and therapeutic approaches for lifestyle diseases.
4. Explore alternative therapies, including Ayurveda, yoga, and nutraceuticals.
5. Develop research skills through data analysis, surveys, and case studies.

Contents

Unit I: Introduction: Overview of lifestyle-associated disorders, including obesity, diabetes, chronic obstructive pulmonary disease (COPD), cancer, and cardiovascular diseases (CVDs), with a focus on their national and international epidemiological burden. This includes key risk factors, the rising prevalence of obesity and diabetes, and the major public health challenges posed by cancer and cardiovascular diseases.

10 Hours

Unit II: Cancer: History and impact of cancer, characteristics of normal and transformed cells, and the hallmarks of cancer. Understanding the causes, symptoms, pathophysiology of cancer. Cancer related Anaemia and Cachexia. Molecular basis of neoplastic growth, metastasis, key oncogenic pathways, proto-oncogenes, and tumor suppressor genes, tumor viruses and cancer-causing mutations. Diagnosis and Treatment Strategies **-** Biochemical analysis, screening methods, molecular diagnostic techniques, and current treatment options, along with their associated challenges and side effects.

12 Hours

Unit III: Cardiovascular Diseases (CVDs), Obesity, and Diabetes: Cardiovascular Diseases (CVDs): Definition and types including hypertension, coronary artery disease, cerebrovascular disease, cardiomyopathy, atherosclerosis. Obesity and Diabetes: Definition and types including Type 1, Type 2, gestational diabetes, classification of obesity, causes and risk factors such as genetic, metabolic, and lifestyle influences, pathophysiology with insulin resistance, beta-cell dysfunction, metabolic syndrome, molecular mechanisms involving adipokines, inflammation, oxidative stress. Introduction to non-alcoholic fatty liver disease, Diagnosis and Treatment Strategies. CVDs: Diagnostic approaches including biomarkers, treatment strategies focusing on drug discovery, disease management. Obesity and Diabetes: Diagnostic tools including HbA1c, fasting glucose, lipid profile, treatment strategies including lifestyle modifications, pharmacological interventions such as Metformin, GLP-1 agonists, bariatric surgery, emerging therapies.

11 Hours

Unit IV: Recent Advances and Research Scope: Introduction to alternative therapies including Ayurveda, yoga, nutraceuticals, advances in understanding the genetic basis of obesity and diabetes, research on novel drug targets and biomarkers for lifestyle diseases, ethical, social, and regulatory concerns in research and healthcare.

12 Hours

Practicals **30 Hours**

1. Analysis of epidemiological data to assess trends in cancer, obesity, diabetes, and CVDs using public datasets.
2. Paper presentations and group discussions on novel drug targets and discovery of biomarkers.
3. Engage in discussions on lifestyle disorders through case studies and debates. Analyze causes, risk factors, and improvements.
4. Explore modern vs. traditional lifestyles, counseling strategies, and health misconceptions.

Suggested Readings:

- Rippe, J.M. (2024) Lifestyle Medicine (4th Edition), CRC Press, USA
- Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., Walter, P. (2022) Molecular Biology of the Cell (7th Edition), W. W. Norton & Company, USA.
- Kumar, P., & Clark, M. (2017). Kumar and Clark's Clinical Medicine. Elsevier.
- Kumar, V., Abbas, A. K., & Aster, J. C. (2020). Robbins & Cotran Pathologic Basis of Disease. Elsevier.
- DeVita, V. T., & Lawrence, T. S. (2019). Cancer: Principles & Practice of Oncology. Wolters Kluwer.
- Melmed, S. (2015). Williams Textbook of Endocrinology. Elsevier.

Teaching Learning process and Assessment methods

Unit No.	Course learning outcome	Teaching and learning activity	Assessment task
Unit I	Students will gain foundational knowledge of lifestyle-associated disorders, including obesity, diabetes, cardiovascular diseases, COPD, and cancer. They will understand the epidemiology, causes, and physiological impact of these disorders.	Students will be asked to orally revise the previous class before each new session, allowing for better retention and clarification of doubts. Teaching will be conducted using a combination of blackboard and PowerPoint presentations, supplemented by discussions on real-world case studies.	Internal assessment tests (mid-term and end-term) will be conducted
Unit II	Students will explore the molecular mechanisms underlying cancer, including genetic mutations, metabolic alterations, and environmental risk factors. They will develop an understanding of tumorigenesis and its role in disease progression.	Students will be encouraged to engage in peer discussions and case-based learning to analyze cancer mechanisms. Teaching will involve interactive lectures, presentations, and readings of research articles.	Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned topics for presentations and discussions.
Unit III	Students will explore the pathophysiology and molecular mechanisms underlying cardiovascular diseases, obesity, and diabetes. They will analyze genetic, metabolic, and environmental influences contributing to these disorders and their interconnections with other diseases.	Students will participate in problem-based learning sessions to assess and compare different diagnostic techniques and treatment strategies. Teaching will include video demonstrations where possible, along with PowerPoint presentations and discussions.	Internal assessment tests (mid-term and end-term) will be conducted. Students will present case studies and submit short reports on diagnostic tools and treatment interventions.
Unit IV	Students will understand the significance of recent advancements in research, including alternative therapies, novel drug discoveries, and precision medicine in the context of lifestyle disorders.	Students will engage in critical analysis of recent literature, participate in journal club discussions, and present reviews on emerging research. Teaching will involve an integration of interactive lectures, PowerPoint presentations, and active discussions.	Internal assessment tests (end-term) will be conducted. Students will be assigned topics to present research findings and submit a literature review on a selected emerging therapy.

GENERIC ELECTIVE COURSE : GE-01
FOOD AND NUTRITIONAL BIOCHEMISTRY

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		
GE-01 FOOD AND NUTRITIONAL BIOCHEMISTRY	04	03		01	B.Sc. in any area of Life Sciences	-

Number of weeks: 15
Number of hours: 45 (T) + 30 (P)

Learning objectives

The objective of this course is to provide a comprehensive understanding of food and nutritional biochemistry, including the biochemical properties of nutrients, their metabolism, and their role in health and disease. It aims to prepare the students for careers in nutrition research, healthcare, and food technology.

Learning Outcomes

1. Gain knowledge of food components, their classification, biochemical properties, and nutritional value.
2. Understand nutrient absorption, assimilation, and their role in maintaining metabolic balance.
3. Learn about the biochemical basis of nutritional disorders and their prevention, and explore emerging trends in food technology, nutrigenomics, and functional foods.
4. Develop research skills through practical experience in food analysis, nutritional assessments, and data interpretation.

Contents

Unit I: Fundamentals of Food Biochemistry: Concept of nutrition and functions of food. Composition and classification of food components (carbohydrates, proteins, lipids, vitamins, minerals), biochemical properties and functions of macronutrients and micronutrients, food enzymes and their role in digestion, water and electrolyte balance, nutritional value of major food groups (grains, dairy, fruits, vegetables, and meat), concept of balanced diet: definition, components, and importance for maintaining health and preventing nutrient deficiencies.

12 Hours

Unit II: Nutrient Utilization and Nutritional Disorders: Energy balance and basal metabolic rate (BMR), nutrient absorption and assimilation, adaptations during fasting, exercise, and stress, impact of dietary fibers and antioxidants on health, causes and biochemical basis of malnutrition (protein-energy malnutrition, vitamin and mineral deficiencies), nutritional anemias and osteoporosis, role of functional foods and nutraceuticals in disease prevention.

11 Hours

Unit III: Food Technology and Safety: Principles of food preservation (pasteurization, fermentation, and irradiation), food additives and their biochemical effects, genetically modified foods: benefits and risks, food quality assessment techniques, food contamination, toxicology and safety standards.

11 Hours

Unit IV: Emerging Trends in Nutritional Research: Nutrigenomics and personalized nutrition, probiotics, prebiotics, and their health benefits, role of gut microbiota in nutrition and health, importance of colon health in various diseases, role of bioactive compounds in nutrition, functional beverages and plant-based diets, current trends in sports nutrition and dietary supplements.

11 Hours

Practicals: **30 Hours**

1. Group discussions on nutritional disorders, along with presentations and discussions on the relationship between food and medicine.
2. Discussion on impact of probiotics, dietary pattern surveys, sports nutrition, and comparative studies on traditional and modern nutritional therapies.
3. Paper presentation on Nutrigenomics, personalized nutrition and role of gut microbiome.

Suggested Readings:

- Nelson, D. L., & Cox, M. M. (2017). Lehninger Principles of Biochemistry. W. H. Freeman.
- Willey, J.M., Sandman, K., Wood, D. (2019) Prescott's Microbiology (11th Edition), McGraw-Hill Education, USA.
- Wardlaw, G. M., Smith, A. M., & Collene, A. L. (2021). Contemporary Nutrition. McGraw Hill
- Bender, D. A. (2014). Nutritional Biochemistry. CRC Press.
- Gibney, M. J., Lanham-New, S. A., Cassidy, A., & Vorster, H. H. (2019). Introduction to Human Nutrition. Wiley-Blackwell.

Teaching Learning process and Assessment methods

Unit No.	Course learning outcome	Teaching and learning activity	Assessment task
1	Students will understand the composition and classification of food components, including	Students will be engaged in interactive lectures using blackboard and PowerPoint presentations. They will participate in	Mid-term and end-term tests will be conducted. Students will complete case study reports on

	macronutrients and micronutrients. They will learn about food enzymes, digestion, nutritional value, and the concept of a balanced diet.	discussions on food components, their biochemical roles, and dietary balance. Case studies on nutrient deficiencies will be analyzed.	nutritional balance and present findings.
2	Students will explore energy balance, nutrient absorption, metabolic adaptations, and the biochemical basis of malnutrition. They will understand the role of functional foods and nutraceuticals.	Concept-based lectures, group discussions, and problem-solving exercises will be conducted. Students will review case studies on metabolic disorders and analyze dietary interventions.	Mid-term and end-term tests will be conducted. Students will be assigned research projects on nutrient utilization and present their findings.
3	Students will understand food preservation principles, food additives, genetically modified foods, and food safety standards.	Students will engage in hands-on demonstrations on food preservation techniques and participate in debates on genetically modified foods.	Students will complete food quality analysis reports and deliver presentations on food safety regulations. Mid-term and end-term assessments will be conducted.
4	Students will explore the latest research in nutrigenomics, probiotics, gut microbiota, bioactive compounds, and personalized nutrition.	Interactive discussions, literature reviews, and seminar presentations on emerging research trends. Students will critically analyze recent journal articles and research papers.	Students will submit a literature review on a selected topic and present a seminar on emerging nutritional trends. End-term assessment will be conducted.

GENERIC ELECTIVE COURSE: GE-02
ENZYMES AND METABOLIC PATHWAYS

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		
GE-02 ENZYMES AND METABOLIC PATHWAYS	04	03		01	B.Sc. in any area of Life Sciences	-

Number of weeks : 15
Number of hours : 45 (T) + 30 (P)

Learning Objectives:

The objective of this course is to offer detailed knowledge about enzymes, which catalyze the entire repertoire of biochemical reactions in life processes and provide basic concepts of their mechanism of action, kinetics, regulation, inhibition, purification, and diverse applications. This course will also highlight the importance of enzymes in the development of metabolic disorders.

Learning Outcomes:

1. Students will acquire insights into enzyme assays, kinetics, structure, regulation, mechanism of action, reaction intermediates and inhibition.
2. Students will learn various theories for enzyme action and regulation and experimental evidence thereof.
3. Students will learn different examples of metabolic disorders and their mechanisms.
4. Students will be able to develop an understanding to use enzymes for diagnosing metabolic disorders

Contents

Unit I: Enzymology: Introduction, General characteristics of enzymes, Activation energy, Active site and its importance, Enzyme activity; Specific activity and Units; Classification and nomenclature of enzymes. Optimization of enzyme assays. Factors influencing catalytic efficiency and the mechanisms employed. Enzyme kinetics: Significance; Rapid Equilibrium and Steady State approach, Henry- Michaelis-Menten's and Haldane equations, Significance of Km, Catalytic efficiency and turnover number; Kinetic perfection. Order of kinetics. Methods of plotting enzyme kinetics data:

12 Hours

Unit II: Regulation and control of enzyme activity: Isozymes, Zymogens, reversible covalent modification, irreversible covalent modification, Enzyme Inhibition, Reversible and Irreversible inhibition, Models and types of inhibition; Kinetics and diagnostic plots related to enzyme inhibition, Dixon plots, Multisubstrate enzymes; Multisite and Allosteric enzymes; Models and examples.

11 Hours

Unit III: Enzymes involved in glycolysis, pentose phosphate pathway, Krebs cycle, glucose and amino acid metabolism, and its enzymes. Metabolic disorders and its enzymatic association. Applied Enzymology: Application of enzymes in industry, diagnostics and medicine, agriculture, research; Immobilized enzymes. Case studies. Synthetic or artificial enzymes and Enzyme engineering

11 Hours

Unit IV: Allosteric regulation of Phosphofructokinase, Aspartate transcarbamoylase, Streptokinase, Urokinase etc. Enzymes in the diagnosis of metabolic disorders, Phenylketonuria, Hyperglycinemia, Homocystinuria, and Maple syrup urine disease.

11 Hours

Practical- **30 Hours**

1. Video demonstrations and simulations on Enzyme kinetics model and mechanisms
2. Case studies on enzyme designing and inhibition
3. Group activities on Phenylketonuria, Hyperglycinemia, Homocystinuria, and Maple syrup urine disease case studies

Suggested Readings:

1. I.H. Segel. 2010. Biochemical Calculations (2nd Ed), John Wiley and Sons, California, USA. ISBN: 978-0-471-77421-1.
2. P. F. Cook, W.W. Cleland. 2007. Enzyme Kinetics and Mechanism, Garland Science Publishing, London, England and New York, USA. ISBN: 978-0815341406.
3. T. Palmer, P. Bonner. 2007. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry (2nd Ed.), Woodhead Publishing House, Chichester, England. ISBN: 978-0- 857099921.
4. R. Burgess, M. P. Deutcher. 2009. Guide to Protein Purification (2nd Ed.), Academic Press, San Diego, USA. ISBN: 978-0-12-374978-9.
5. D. Purich. 2010. Enzyme Kinetics: Catalysis and Control (1st Ed.), Academic Press, San Diego, USA. ISBN: 978-0-123809247.

Teaching Learning process and Assessment methods

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will learn about general properties of enzymes like activation energy, active site, etc.; definition of enzyme activity and its various units; classes of enzymes and international nomenclature; they will learn how to perform and optimize enzyme assays; types of enzyme assays; General mechanisms that enzymes employ to attain kinetic perfection and mechanism of catalysis at molecular level.	Outlining history of development of knowledge about enzymes through power point presentations and reading of landmark publications; Question and answer sessions in the class.	Assignments to calculate units of enzyme activity; Classification of assigned enzymes and their nomenclature. A specific enzyme will be assigned to each student and they will need to develop protocol for enzyme assay. Case studies for model enzymes.
II	Importance of investigating enzyme kinetics; the important kinetic parameters like Km, Vmax, Kcat, etc.; derivation of Michaelis-Menten equation; Order of kinetics; Students will learn how to plot experimental data into various forms to calculate various kinetic parameters and advantages and disadvantages of each method. Students will learn how to measure fast Kinetics.	The basic concepts will be explained using chalk and board; Original paper by Michaelis-Menten will be discussed. Power point presentations for better representations. Student interaction in class.	Students will be asked to derive MM equation without help. Numerical problems to estimate kinetic parameters. Students will be asked to rearrange MM equation to derive various equations which underlie each linear plot. Experimental data will be provided to plot data and derive parameters using graph papers. Students will read papers on fast kinetics and discuss about the principles in class in groups of 3.

III	Students will learn about the various types of metabolic disorders; and their associated enzymes.	Concepts will be taught using chalkboard and PowerPoint presentations; Research papers will be provided for applications; Numerical problems will be solved.	Numerical problems on various types of metabolic disorders. Identification of types of human metabolic disorders and their mechanism
IV	Students will learn how metabolic disorders are genetic in nature. Enzymes in the diagnosis of metabolic disorders	Chalk and Board for teaching the basic concepts; Powerpoint presentations for better representations.	Students will be asked to compare different metabolic disorders and their comparison. How enzyme-based diagnostics can be evolved

SKILL ENHANCEMENT COURSE : SEC-01
ICT TOOLS FOR BIOCHEMISTRY

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		
SEC-01 ICT TOOLS FOR BIOCHEMISTRY	02	0		02	-	-

Number of weeks: 15
Number of hours: 60 (P)

Learning Objectives:

This course aims to provide skill and hands on training about the basic information technology computer-based tools that are routinely required for learning, analysis, writing, presentation and data analysis.

Learning Outcomes:

1. Students will gain the skill of various online ICT tools and will be able to use these tools for drafting scientific writing, assignments, term papers etc.
2. Students will be able to make presentations, interactive drawings and images etc.

Contents

Unit I: Microsoft word, Microsoft powerpoint, Microsoft excel, google classroom, Microsoft teams, online meeting and video conferencing tools. Formatting of documents, use of add on features, analysis of data using MS-Excel, Creation of graphs and charts, Export and Import of data, Preparing slides in powerpoint, use of animation functions, clipart and other features, Use of formula function in Excel.

35 hours

Unit II: Online quiz tools, Google forms for survey, Biorender and other online tools for making publication figures and images. Chemdraw to make structures. Online platforms like Canva for making documents and presentations, NCBI and PubMed for accessing literature and databases. PDB for accessing protein structures.

25 hours

Teaching Learning process and Assessment methods

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will learn about general usage of various ICT tools like MS word, powerpoint, excel etc, which will assist the students in scientific writing, making presentations, data plotting, making data graphs etc.	Students will be taught via videos about the functioning of the ICT tools. Demonstrations and hands-on training will be conducted for the usage of these tools.	Assignments will be conducted to assess the learning of the students. Quiz will be also be conducted for the same.
II	Students will learn about general usage of various ICT tools that are useful for attempting quizzes, improving English writing and for making scientific images and figures.	Students will be taught via videos about the functioning of the ICT tools. Demonstrations and hands-on training will be conducted for the usage of these tools.	Assignments will be conducted to assess the learning of the students. Quiz will be also be conducted for the same.

SKILL ENHANCEMENT COURSE : SEC-02
ARTIFICIAL INTELLIGENCE AND ITS APPLICATIONS IN BIOCHEMISTRY

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		
SEC-02 Artificial Intelligence and its Applications in Biochemistry	**02**	**0**		**02**	-	**-**

Number of weeks: 15
Number of hours: 60 (P)

Learning Objectives:

This course aims to provide skill and hands on training about some advanced information technology computer-based tools that are routinely required by all the students for learning, analysis, writing, referencing, video editing etc.

Learning Outcomes:

1. Students will gain the skill of using various online web-based AI tools and will be able to use these tools for making and editing sound embedded videos, protein and DNA analysis, protein structure prediction, protein interaction, analysis of omics data.
2. Students will be able to make videos, edit videos, make movies and visualize structures, perform protein structure prediction, primer designing, DNA structure analysis and analysis of omics data.

Contents

Unit I: Role of AI and Machine Learning in biomedical sciences**,** AI tools for data mining and analysis, AI detection tools, Video editor, OBS studio, open shot editor, movie making, PyMOL for 3D visualization of biomolecules, AI for Small Molecule Analysis & Drug Discovery, PubChem for small molecule compounds & AI-assisted molecule screening, AI docking tools for protein-ligand interaction, AI-driven QSAR modeling for drug prediction. Web based tools for Molecular biology –primer designing, Uniprot, GEO database, case studies on use of ML for biological datasets

40 hours

Unit II: AI-Based Protein Structure Prediction**,** ExPASy tools for protein sequence analysis, comparative homology modelling of proteins, Structure superimposition, RMSD analysis, protein-protein interaction prediction tools (STRING etc.), analysis of NGS and other omics data, heatmap generation, pathway analysis, gene enrichment, network analysis tools,

20 hours

Teaching Learning process and Assessment methods

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will learn about general usage of various tools for AI detection, video editing etc. protein and DNA analysis, protein structure prediction, protein interaction, analysis of omics data	Students will be taught via videos about the functioning of the web based tools. Demonstrations and hands-on training will be conducted for the usage of these tools.	Assignments will be conducted to assess the learning of the students. Quiz will be also be conducted for the same.
II	Students will learn about general usage of various tools that are useful for visualisation and analysis of protein structures, protein structure prediction etc, protein interaction and omics data analysis.	Students will be taught via videos about the functioning of the ICT tools. Demonstrations and hands-on training will be conducted for the usage of these tools.	Assignments will be conducted to assess the learning of the students. Quiz will be also be conducted for the same.

Annexure-2

TWO YEAR
MASTERS IN GENETICS
POST GRADUATE PROGRAMME
(Semester 1 & 2 effective from 2025)

DEPARTMENT OF GENETICS
UNIVERSITY OF DELHI SOUTH CAMPUS

Disclaimer: The syllabi uploaded are as approved by the Academic Council on 10.05.2025 and Executive Council on 23.05.2025

CONTENT PAGE

About the Department

The Department of Genetics was established in 1984, as a part of the Faculty of Inter-disciplinary & Applied Sciences at the University of Delhi South Campus (UDSC). The department over the years has emerged as a strong hub for training students and for pursuing quality research in two broad areas of food and health, both with significant societal impact.

Notable scientific contributions from the department in the recent past include i) screening of 200,000 newborns for inborn errors of metabolism collaborating with 20 hospitals across the Delhi state, and generating the first ever epidemiological and genetic data for over 45 common and rare genetic disorders in the country- a good example of translational research and technology for the masses; ii) discovery of putative causal genes for a few brain disorders; iii) spearheading research on transgenic mustard for hybrid seed production, approved by the Genetic Engineering Approval Committee (GEAC) - a first such translational product from any university in India; and iii) development of non-transgenic hybrids of mustard with improved oil quality which has already reached the farmer's field.

The two-year post-graduate (M.Sc.) program, the new one-year post-graduate program and the Ph.D. program offered by the department are based on this strong foundation of research. The department enjoys a unique strength of having teaching faculty with research specialization using a range of model systems such as *Drosophila*, *Arabidopsis*, Yeast, *Dictyostelium*, and human cell-line models. The M.Sc. program is open to students with Bachelor's degree in any area of science (biological/chemical/physical) through a national level entrance test. The curriculum spread over four semesters, aims at teaching not only the basics of the science of heredity but also emerging concepts in almost all related disciplines of biology. Another distinct feature of this course is the hands-on-training imparted to the students. Emphasis is given to laboratory based learning including a small project work during the fourth semester wherein students are encouraged to conceptualize, design and perform experiments to answer a basic question related to their respective mentors' research programme, trouble shoot, interpret their data, write a report and also give an oral presentation at the end of the semester. The approach of a restrictive practical performed in a narrow time-frame is not supported, thus giving all students an opportunity to hone their skills across semesters.

Students with Master's degree in any area of sciences with an aptitude to work in the broad research programs of the department are selected for the Ph.D program based on a national level entrance test/interview and have to complete a 12 credit course before they can proceed with their experimental work. Ph.D work generally spans over five to six years followed by a rigorous thesis defense and *viva-voce* examination.

Research is an integral part of the departmental academic activity. Research programs of the faculty using cutting edge technology are focused on basic aspects of genetics, genomics and molecular biology with direct implications for crop improvement and health/disease. Specific projects under the plant sciences include high resolution mapping and marker assisted breeding in mustard; development of pathogen using RNAi technology; understanding plant-pathogen interactions using conventional and contemporary OMICS approaches in *Arabidopsis* and Tobacco; and unraveling promoter architecture for regulation of transgene expression in plants. Biomedical research projects include identification of pre-disposing and somatic mutations in cancer using liquid biopsy and tissues, studying molecular mechanisms in cancer stemness, progression and therapy in the microenvironment; determining molecular mechanisms underlying cellular toxicity and polyQ induced neurodegeneration in Huntington's and Parkinson's diseases using *Drosophila* as a model system; studying gene-emvironment interactions, understanding cell signaling in stress and development with *Dictyostelium* as a test system; and mitochondrial genetics and ribosomal biology using yeast provide insights into important basic biological processes.

Research projects in the department have attracted generous funding support from various agencies including Department of Biotechnology (DBT), Indian Council of Medical Research (ICMR) Anusandhan National Research Funding (ANRF, erstwhile Science and Engineering Research Board), Council of Science and Industrial Research (CSIR) and University Grants Commission (UGC). The department houses two Centres of Excellence supported by DBT and ICMR. The department has also been recognized and supported by UGC-SAP (DRS-III) and DST-FIST (level II) programs. Ph.D. scholars in the department are encouraged to avail independent fellowships and are also supported with fellowships from the university or extramural grants. A well-equipped instrumentation facility for imaging, genomics, proteomics and transcriptomics both in the department as well as the Central Instrumentation Facility of South Campus have been an exemplary support for carrying out high quality research.

Finally, contemporary and relevant syllabi for the Master's course, ongoing research projects of societal relevance together with dedicated and high performing doctoral students and faculty have enabled the department of genetics to emerge and stay in the forefront of teaching and research in different branches of Genetics in the country.

Adoption of the New Education Policy

The University has adopted the new education policy which brings flexible education system, gathering of credit points and possibility of lifelong learning into the education system. For this UGC has drafted three documents that are relevant to the PG programme being offered by the Department of Genetics.

These documents can be accessed here in their entirety:

1. The National Education Policy 2020 (https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pd
2. National Credit Framework (NCrF) (https://www.ugc.gov.in/pdfnews/9028476_Report-of-National-Credit-Framework.pdf
3. The National Higher Education Qualifications Framework (NHEQF) (https://www.ugc.gov.in/pdfnews/2990035_Final-NHEQF.pdf)
4. Post-graduate curriculum framework 2024 (PGCF 2024) based on NEP2020, as approved by Academic Council on 27th December 2024

Excerpts from the aforementioned document pertinent to the Department are shared below:

The NEP 2020 envisages flexibility in the designs and duration of Master's degree programmes: The structure and duration of master's programmes of study proposed by the NEP 2020 include:

- a 2-year Master's programme (with the option of having the second year devoted entirely to research) for those who have completed a 3-year Bachelor's programme;
- a 1-year Master's programme for students who have completed a 4-year Bachelor's degree; and
- an integrated 5-year Bachelor's/Master's programme.
- A Ph.D. programme shall require a Master's degree or a 4-year Bachelor's degree.

The National Credit Framework (NCrF) provides for Assignment, Accumulation, Storage, Transfer & Redemption of Credits. It paves way for multi-disciplinary education and empowers students through flexibility in choice of courses for choosing their own learning trajectories and programmes, and thereby choose their paths in life with appropriate career choices, including option for mid-way course corrections, according to their talents and interests.

Credit and Credit Points

'Credit' is recognition that a learner has completed a prior course of learning, corresponding to a qualification at a given level. For each such prior qualification, the student would have put in a certain 34 volume of institutional or workplace learning, and the more complex a qualification, the greater the volume of learning that would have gone into it.

(i) Credits quantify learning outcomes that are subject achieving the prescribed learning outcomes to valid, reliable methods of assessment.

(ii) The credit points will give the learners, employers, and institutions a mechanism for describing and comparing the learning outcomes achieved. The credit points can be calculated as credits attained multiplied with the credit level.

The National Higher Education Qualifications Framework (NHEQF) explains:

Table 11: Qualification type and credit requirement (given on Page 45 and 46 of NHEQF document)

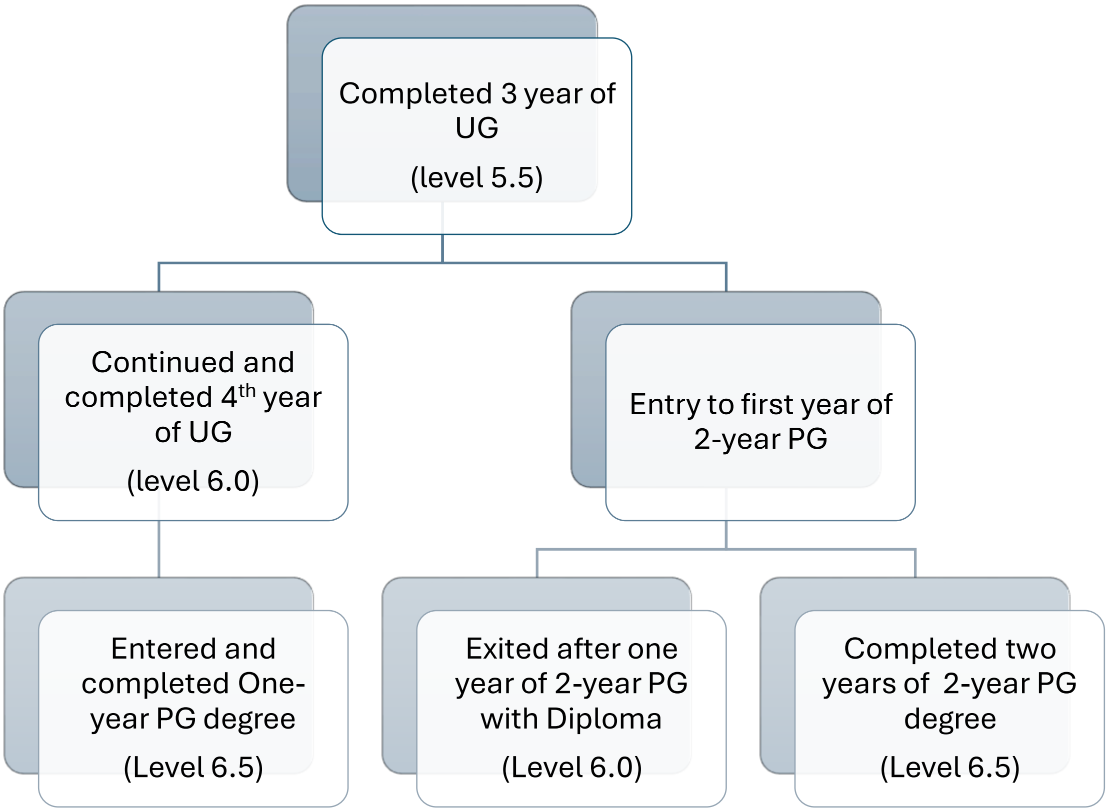
NHEQF levels	**Qualification title/nomenclature**	**Credit Requirements (Minimum)**
Level 6	Post-Graduate Diploma. For those who exit after successful completion of the first year or two semesters of the 2-year master's programme). (Programme duration: One year or 2 semesters).	40 credits
Level 6.5	Master's degree. (e.g. M.A.; M.Com., M.Sc.; etc.) (Programme duration: Two years or four semesters after obtaining a 3-year Bachelor's degree).	80 credits
Level 6.5	Master's degree (e.g. M.A.; M.Com., M.Sc.; etc.) (Programme duration: One year or 2 semesters after obtaining a 4- year Bachelor's degree (Honours/ Honours with Research).	40 credits
Level 7	Master's degree (e.g. M.E.; M.Tech. etc.) (Programme duration: Two years or four semesters after obtaining a Bachelor's degree (e.g. B.E., B.Tech.etc.).	80 credits

Table 12. Letter Grades and Grade Points (Page 46 of the NHEQF document)

Letter Grade	Grade point
O (outstanding)	10
A+ (Excellent)	9
A (Very good)	8
B+ (Good)	7
B (Above average)	6
C (Average)	5
P (Pass)	4
F (Fail)	0
Ab (Absent)	0

Post graduate Programmes offered by the Department

From 2025, the NEP structure shall apply to the post-graduate programme of Department of Genetics. The overview of entry and exit from the 1-year and 2-year post graduate degree program is given, including the possibility of exit with diploma, as and how mandated by the University guidelines



If a 4th year UG (meeting the required eligibility) enters and completes the 2 year PG program they exit at the end of two years with Level 7 of Master's degree.

Programme Eligibility & Admission

The Department of Genetics will offer both 1 year Masters in Genetics (1Y-PG) and 2 year Masters in Genetics (1Y-PG) programmes.

Eligibility and Qualifications

Programme	Last qualifying exam	Course Eligibility	Mode of admission
1 year PG	4 year UG	Bachelor's Degree in any branch of Life Sciences/ Biology/Physical Sciences/ Chemical Sciences/ Medical Sciences/ Pharmacology from a recognized University.	As per University guidelines
2 year PG	3/4 year UG	Bachelors in any discipline of sciences or allied sciences/ BTech/ MBBS	As per University guidelines

Programme objective

TWO-YEAR MSC :

This program is aimed at graduate students from any field of science who want to pursue research careers in specialized area of biological science. The program focuses at developing strong foundational skill in various fields of genetics. In addition to fundamentals, the students are exposed to core areas in Molecular Genetics (microbial, *Drosophila,* plants and humans) as well as related areas like Biochemistry, Biostatistics, Developmental Biology, Recombinant DNA Technology and Computer Applications. Apart from the core courses, students can select few courses of their preference from a bunch of elective courses. Special emphasis is given on intensive lab practical sessions, as well as hands on for bioinformatics data analysis where every student gets a chance to independently perform the experiments and gain experience with standard molecular biology and genetic tools. Class room seminars, discussions, written tests, project work and hands on practical training are integral components of the course. In two structures, research dissertation is also included. The syllabus is updated regularly to reflect the important advances in the related field. Students are continuously evaluated during the course. Various scholarships viz., Merit Scholarship, All India Post Graduate Scholarship and Monsanto Post Graduate Scholarship are also available for the M.Sc. students. Students are encouraged to clear UGC/CSIR-NET while pursuing their M.Sc. course.

ONE-YEAR MSC

This program is aimed at graduate students from any field of science after the completion of four years of undergraduate degree and who want to pursue research careers in specialized area of biological science. A student entering this course will need to have a basic understanding of related areas of life sciences. The program focuses at developing strong foundational skill in genetics, wherein concepts of genetics will be taught using one or more model systems (microbial, *Drosophila,* plants and humans). Under the various structures, students can select few courses of their preference from a bunch of elective courses. Where the Structure has more of coursework, the Experiments in Genetics paper has been added to give the students a flavour of the strength of the department. In structures with Research projects, the students can choose elective research areas that align with their projects to gain a comprehensive skillset. Class room seminars, discussions, written tests, project work and hands on practical training are integral components of the course. The syllabus will be updated regularly to reflect the important advances in the related field. Students are continuously evaluated during the course. Various scholarships viz., Merit Scholarship, All India Post Graduate Scholarship and Monsanto Post Graduate Scholarship are also available for the M.Sc. students. Students are encouraged to clear UGC/CSIR-NET while pursuing their M.Sc. course.

Assessment of Students' Performance and Scheme of Examinations

1. English shall be the medium of instruction and examination.
2. Assessment of students' performance shall consist of end semester examination and internal assessment.
   i. For theory papers 30% of the total marks will be allotted for internal assessment. Internal assessment can be in the form of mid-term examination, assignments, quizzes or presentations including attendance (5%). The concerned teacher will inform the students of the mode of internal assessment at the beginning of the semester.
   ii. Practical papers will consist of continuing assessment (15% of the total marks) based on weekly appraisals of the work carried out by the student, a viva-voce examination (25% of the total marks) and an end of term practical examination (60% of the total marks).
   iii. Project work will be evaluated based on continuing assessment of the work by the supervisor, two presentations made by the students and a final detailed report of the work to be submitted by the student. The presentations and the report will be assessed by teachers other than the supervisor. The distribution of marks will be informed to the student at the beginning of the semester.

Definitions

(i) ‘Academic Programme’ means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/Centre.

(ii) ‘Course’ OR ‘Paper’ means a segment of a subject that is part of an Academic Programme.

(iii) ‘Programme Structure’ means a list of courses (Core, Elective, General Elective) that makes up an Academic Programme, specifying the syllabus, credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity with University rules, eligibility criteria for admission.

(iv) ‘Core Course’ means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course

(v) ‘Elective Course’ means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre.

(vi) ‘General Elective’ means an elective course which is available for students of all programmes, including students of the same department. Students of other Departments will opt these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

(vii) ‘Credit’ means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course.

(viii) ‘SGPA’ means Semester Grade Point Average calculated for individual semester.

(ix) ‘CGPA’ is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

(x) ‘Grand CGPA’ is calculated in the last year of the course by clubbing together of CGPA of two years, i.e., four semesters. Grand CGPA is being given in Transcript form. To benefit the student a formula for conversation of Grand CGPA into % marks is given in the Transcript.

Quick References For Navigating Through The Courses

Often used abbreviations:

2Y-PG : 2 year post graduate programme
1Y-PG : 1 year post-graduate programme
DSE : Discipline specific elective
DSC : Discipline specific core
SBC : skill based course (2c)
RP or R : Research project
TR : Tools for Research
GE : General Elective
S1 : Structure 1
S2 : Structure 2
S3 : Structure 3
Th : Theory
P : Practical
T : Tutorial
E : elective
C : core

Example of a representation of course content:

The following representation is of the paper 'XYZ' as shown on the title page where its detailed course content is given, under the Structure 1, Coursework (marked as S1) offered in Semester 3. In this representation the course of 2 year post graduate program is given (marked as 2Y-PG)

SEMESTER 1; S1 **DISCIPLINE SPECIFIC CORE** 2Y-PG

GEN-XXX
XYZ course/paper

This paper may be also present in Structure 2 or 3 of Sem III/IV also and its content will be represented again along with all other papers

MSC GENETICS – TWO YEAR DEGREE PROGRAM

Course Structure and Credits Overview

Students enter into this program after three years of graduation from any discipline in Science through an entrance exam only. **After completion of their one year (Semester 1 & 2), which is exactly the same for all 2 year PG students-** they will enter into three possible Structures in their second year (Semester 3 & 4) as prescribed by the University.
Their entry into these Structures will be in consultation with the Department based on available infrastructure, facilities and teaching faculty. These structures have been prescribed based on the distribution of core (C), elective (E), 2 credit course skill based course (2c/SBC) and research project (R) component. Our department has been keeping experimental training in the forefront of our Masters programs enabling our students to seek research as a career option. Therefore, we have incorporated our experimental training based on the theory being taught as a Core subject wherever permissible. The credits under each course type are divided into Theory/Lecture (L), Practical (P) and Tutorial (T) as per the norms shared by the University. The division is shown along with the course content of every semester.

1 credit = 15 hours of teaching/30 hours of practical/15 hours of tutorials

Distribution Of Course Types Under Each Structure When The Students Exit Msc Genetics (2Y) Program

	Core	Elective	2 credit courses	Research project	Credits earned at exit of MSc-2Y PG
Structure 1	40	40	8	0	88
Structure 2	40	32	4	12	88
Structure 3	28	24	10	26	88

Overview Of The Structures Available To Msc. Genetics (2Y Program) – Semester-Wise Distribution

	Semester 1 (same courses for all)				Semester 2 (same courses for all)				Semester 3				Semester 4				Total credits
	C	E	2c	R	C	E	2c	R	C	E	2c	R	C	E	2c	R	
Structure 1	12	8	2	0	12	8	2	0	8	12	2	0	8	12	2	0	**88**
Structure 2	12	8	2	0	12	8	2	0	8	8	0	6	8	8	0	6	**88**
Structure 3	12	8	2	0	12	8	2	0	4	4	4	10	0	4	2	16	**88**

C: Core; E: Elective (Discipline specific/Open); 2c (2 credit core courses); R: Research project

Note regarding Electives:
Elective courses are either Discipline specific elective (DSE, offered by the department of genetics) or general elective (GE, offered by other departments) Students can either opt for all DSE offered by its own department or opt for ANY ONE of the GE by other department in addition to other DSE(s) to complete their quota of electives in a particular semester.

The syllabus for M.Sc. Genetics (Semester I and II) has been structured as follows:

Sem 1&2	Distribution of credits that a student needs to complete under course types				
Course Distribution	**Core (DSC)**	**Electives (DSE/GE)**	**2-Credit core course (SBC)**	**Research Project (R)**	**Total**
Number	3	2 (2DSE+0GE; 1DSE+1GE)	1	0	**6**
Credits	12	8	2	0	**22**
Student needs to complete 12+8+2+0 = 22 credits in each semester					

SEMESTER 1 (2Y-PG)

PAPERS OFFERED						
Course Code	**Type**	**Title**	**Credits**	**Credit distribution**		
				L	T	P
DSC-GEN-101	DSC	Biological Processes and Patterns of Inheritance	4	3	0	1
DSC-GEN-102	DSC	Genes, Genomes and Chromosomes	4	3	0	1
DSC-GEN-103	DSC	Experiential learning in Genetics - I	4	0	0	4
DSE-GEN-104	DSE	Molecular Biology	4	3	1	0
DSE-GEN-105	DSE	Cell Biology	4	3	1	0
DSE-GEN-106	DSE	Enzymology and Metabolism	4	3	1	0
GE-GEN-110	GE	Genetics in Crop Improvement	4	3	1	0
SBC-GEN-111	SBC	Statistical Analysis in Biology	2	1	0	1
Distribution of total theory, practical and tutorial in Sem 1			22	13	2	7

SEMESTER 2 (2Y-PG)

PAPERS OFFERED						
Course Code	**Type**	**Title**	**Credits**	**Credit distribution**		
				L	T	P
DSC-GEN-201	DSC	Regulation of Gene Expression	4	3	0	1
DSC-GEN-202	DSC	Recombinant DNA Technology	4	3	0	1
DSC-GEN-203	DSC	Experiential learning in Genetics-II	4	0	0	4
DSE-GEN-204	DSE	Development Biology	4	3	1	0
DSE-GEN-205	DSE	Immunology & Immunogenetics	4	3	1	0
DSE-GEN-206	DSE	Mitochondrial Biology & Connection to Cell Physiology	4	3	1	0
GE-GEN-210	GE	Genetics in Everyday Life: From DNA to Society	4	3	1	0
SBC-GEN-211	SBC	Microscopy and Imaging	2	1	0	1
Distribution of total theory, practical and tutorial in Sem 2			22	13	2	7

Notable value addition in courses types offered by Department of Genetics

The M.Sc. Genetics program in Semesters I and II is carefully structured to balance theoretical understanding with practical application.

The 4 Credit Practical DSC

Over the years, the Department of Genetics has moved away from conventional, stand-alone "boxed" experiments toward a more open-ended, inquiry-driven pedagogical approach. Our emphasis is not on teaching protocols or fixed techniques but on encouraging students to explore, experiment, and question.

This often leads to surprising observations, fostering discussions and deeper understanding. Such experiences spark curiosity, build scientific temper, and nurture the courage to question—an essential quality for any researcher or professional. These practical modules are designed as continuous investigative experiences, not just technical routines. Through this process, students also gain essential research skills such as data collection, analysis, scientific writing, and presentation. The goal is to help students understand core concepts and begin thinking and working like scientists.

Role Of Tutorials In Our Curriculum

Tutorials in our curriculum are not just meant for clearing doubts. While, they remain a space for one to one interactions, they been designed in a manner that they can be used to discuss important scientific discoveries and encourage open debates. Students get a chance to read, present and discuss key research papers, helping them understand how scientific ideas are developed and tested over time. Together, these elements make tutorials a vital part of our curriculum, helping students think critically, communicate effectively, and engage with the scientific process.

The 2 Credit Skill Based Courses

The skill-based courses in line with the NEP emphasis on experiential, hands-on learning along with academic knowledge. These subjects equip students with essential tools for scientific inquiry—biostatistics trains them in quantitative reasoning and data analysis using software platforms relevant to modern biology, while microscopy builds a skill important in the research field and for studying many biological processes. Both have strong cross-disciplinary relevance, contributing to fields as diverse as genetics, public health, biotechnology, environmental science, and clinical research. By working with real data, instruments, and analytical methods, students will develop competencies that are directly applicable in research and industry settings, enhancing both their academic foundation and career readiness.

COURSE DETAILS

ALL PAPERS OFFERED IN SEMESTER 1 OF THE 2Y-PG

DSC-GEN-101

Biological Processes and Patterns of Inheritance

***Course Objective**: The undergraduate genetics course typically focuses on inheritance patterns through ratios and numbers, often presented as an isolated subject without connections to broader biological processes. This course aims to bridge that gap by linking previously learned concepts to various biological mechanisms, fostering a deeper understanding and greater conceptual clarity for students. The syllabus reflects the various areas that will be covered, not necessarily in a linear fashion but by cross-referencing between units to enhance integrated learning. This is a primer to an advanced course to be offered in semester III. The experiential learning included in this paper would lead to appreciation of organisms and develop observational skills of learners.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-GEN-101 Biological Processes and Patterns of Inheritance	4	3	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	
Theory		
I	Biological Processes	
II	Variation: Key to Inheritance Biology	
III	Inheritance patterns	
IV	The Good, The Bad, The Ugly	
Practical		
I	Introduction to Model Organisms - Observation and Handling	
II	Tracking Variations- Identifying Mutant Phenotypes	

Course Outcome: On completing 'Biological Processes and Patterns of Inheritance' the students would have:

- Developed a holistic understanding of genetic principles, inheritance patterns, genetic variation, and molecular mechanisms governing phenotypic expression, linking classical concepts to broader biological processes.
- Analysed genetic variation and its role in Inheritance by exploring mutation sources, allele interactions, recombination, and the use of genetic markers to track variations, and diversity in populations.
- Critically examined the impact of genetics on medicine, agriculture, and society.
- Learnt the nuances and developed appropriate skills of handling and maintaining organisms for genetic analysis.
- Developed keen observational powers, a key to being a good geneticist

Content (Theory)

I. Biological Processes 10 hours

- Life Cycles of Organisms
  - A comparative overview with examples from microbes, plants and animals with reference to genetic analysis
- Cellular Basis of Inheritance
  - Mitosis and Meiosis: A comparative analysis as mechanisms ensuring genetics consistency versus genetic diversity
  - Fertilization: restoring diploidy, introducing variability through gamete fusion.
  - A review of cell structure and developmental processes with reference to inheritance patterns
- Molecular basis of phenotypic expression
  - Dominant, recessive, co-dominant, incomplete dominant phenotypes
  - Biochemical pathways as foundation to phenotypic outcomes due to gene interactions
  - Influence of environment
  - Pleiotropy, penetrance and expressivity.

II. Variation: Key to Inheritance Biology 8 hours

- Sources
  - Mutations: spontaneous versus induced including molecular basis
  - Defining alleles including test for allelism
  - Role of independent assortment and recombination in genetic diversity
  - Horizontal gene transfer
- Tracking variations
  - Phenotypic versus molecular markers
  - Isozymes, allozymes and DNA markers with examples (basic concepts not techniques)
  - Genetic diversity in population: the power of SNPs

III. Inheritance patterns 24 hours

- Mendel's experiments
  - History including the lesser-known contributions of Festetics
  - Experimental design with observations that extend beyond Mendel's classical "Laws."
  - From Mendel's 'characters' to genes – an example of forward genetics
- Chromosomal behaviour and inheritance patterns
  - Segregation
  - Independent assortment
  - Linkage with an introduction to the concept of genetic maps
  - Application of probability and statistics in genetic analysis
- Analysing inheritance patterns
  - Comparison between diploids and haploids
  - Crosses versus pedigree analysis
  - Single gene inheritance patterns
  - Patterns due to gene interaction

- Polygenic inheritance and Quantitative traits
- Cytoplasmic and maternal inheritance

IV. The Good, The Bad, The Ugly 3 hours

- The Good:
  - Genetic Disease Screening and Prevention
  - Personalized Medicine
  - Improvements in Agriculture
- The Bad:
  - Genetic discrimination
  - Unintended consequences of gene editing
- The Ugly:
  - Eugenics and Genetic Purity Movements
  - Designer Babies and Ethical Dilemmas
  - Lysenkoism and Political Suppression of Genetics

Content (Practical) 20+10 hours

I. **Introduction to Model Organisms - Observation and Handling:** Hands-on training in identifying, observing, and safely handling commonly used model organisms for genetic analysis exemplified by *E. coli*, phages, yeast, *Dictyostelium*, *Arabidopsis*, and *Drosophila*. Emphasis on learning to distinguish different life stages, understanding their wild type phenotypes, and becoming familiar with the laboratory setups required for their growth, development and maintenance.

II. **Tracking variations – identifying mutant phenotypes:** Using *Drosophila* as a model students would be given experiential training to describe mutant phenotypes and identify them using AI tools and Drosophila databases.

Suggested Reading (editions to be informed by teacher)

1.	Introduction to genetic analysis	Griffith AF et al	WH Freeman &co
2.	Concepts of Genetics-	Klug WS &Cummings MR	Prentice -Hall
3.	Genetics - a conceptual approach	Pierce BA	WH Freeman &Co
4.	Genetics Analysis	Phillip Meneeley	Oxford press

DSC-GEN-102
Genes, Genomes and Chromosomes

Course Objective: *This paper has been designed to provide fundamental and advanced aspects of chromosome biology, genome organization, concept and mapping of genes, and outshoots. The students are expected to develop a holistic notion about the dynamic nature of chromosomes and their influence in regulating various aspects of cellular functioning and the organism as a whole. Emphasis would be given to explain the topics with the help of interactive classroom sessions including classical experimental strategies, examples from different model organisms, and contemporary genetic approaches and methods.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-GEN-102 Genes, Genomes and Chromosomes	4	3	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	
Theory		
I	Chromatin/ chromosome structure, organization, and anomalies	
II	Concepts and methods to study gene, genome and chromosome organization	
III	Cytogenetic aspects of cell division	
IV	Sex determination and dosage compensation	
Practical		
I	Visualizing chromosomes	
II	Analysing chromatin	

Course Outcome: On completing 'Genes, Genome & Chromosomes' the students would have:

- Understood chromosome structure and organization and gained knowledge of chromatin architecture, chromosome morphology, functional chromosomal domains, and the impact of structural anomalies on cellular function.
- Developed an understanding of gene and genome organization by examining gene structure, genome complexity, repetitive DNA, transposable elements, and their roles in genome evolution and function.
- Learnt cytogenetic techniques and sex determination and explored chromosome analysis methods, cell division regulation, chromosomal non-disjunction, and mechanisms of sex determination and dosage compensation
- Been equipped with practical training in chromosome and chromatin analysis, enabling them to prepare, stain, and interpret cytological samples and understand chromatin organization in somatic and germ cells.

Content (Theory)

I. Chromatin/ chromosome structure, organization, and anomalies 15 hours

- Histones, DNA, nucleosome morphology and higher-level organization
- Functional states of chromatin and alterations in chromatin organization.
- Metaphase chromosomes**:** centromere and kinetochore, telomere and its maintenance, Holocentric chromosomes, Heterochromatin and euchromatin, position effect variegation
- Chromosomal domains (matrix, loop domains) and their functional significance, Nuclear speckles, Long-range chromosomal interactions, Chromatin remodeling.
- Polytene and lampbrush chromosomes, and their biological significance.
- Overview of numerical and structural alterations, and their impact on cellular functioning and development, induced chromosomal aberrations in somatic cells.

II. Concepts and methods to study gene, genome and chromosome organization: 16 hours

- Conventional and modern views, fine structure of gene, split genes, pseudogenes, non-coding genes, overlapping genes and multi-gene families.
- Viruses and prokaryotes, Eukaryotes- Organization of nuclear and organellar genomes, C-value paradox, Repetitive DNA - satellite DNAs and interspersed repeat DNAs.
- Transposable elements- Barbara McClintock's experiment of maize, Autonomous and non-autonomous transposons, clonal selection, retrotransposons, LINES, SINES, Alu family, Application of transposons in mutagenesis, genome mapping and evolution.
- Short-term (lymphocyte) and long-term (fibroblast) cultures, chromosome preparations, karyotyping, banding, chromosome labeling, in situ hybridization, chromosome painting, comparative genome hybridization, somatic cell hybrids and gene mapping, and single cell omics.

III. Cytogenetic aspects of cell division: 8 hours

- Chromosome labeling and cell cycle analysis,
- overview of mitosis and meiosis, sister chromatid cohesion remodeling, regulation of exit from metaphase, chromosome movement at anaphase, genetic control of meiosis
- Non-disjunction of chromosomes

IV. Sex determination and dosage compensation 6 hours

- Genetic determination of sex in *Caenorhabditis elegans*, *Drosophila melanogaster*, mammals and flowering plants.
- Various approaches of dosage compensation. Genetic control of dosage compensation in *Caenorhabditis elegans*, *Drosophila melanogaster*, and mammals.
- Lyon's hypothesis, genetic control of X-chromosome inactivation, XIST and TSIX

Content (Practical) 20+10 hours

I. **Visualizing chromosomes:** This unit deals with the structural and functional aspects of chromosomes using various model organisms and cytogenetic techniques.

- **Preparation and analysis of polytene chromosomes :**

- Dissection and preparation of polytene chromosome squashes from salivary glands of third instar *Drosophila melanogaster* larvae.
- Identification of chromosome arms based on characteristic banding patterns.

- **Study of Mitosis and Meiosis :**
  - Observation and staging of mitosis in onion (*Allium cepa*) root tip cells and in onion flower bud cells.
- **Human karyotype construction and chromosomal aberrations**
  - Construction of human karyotypes from provided metaphase spreads.
  - Identification and interpretation of chromosomal aberrations (numerical and structural anomalies).

II. **Analysing chromatin:** This unit focuses on chromatin structure, nuclear organization, and chromatin-associated features using histological and fluorescence techniques.

- **DAPI Staining of Chromatin in Drosophila**
  - Fluorescent staining using DAPI (4′,6-diamidino-2-phenylindole) to visualize chromatin in somatic and germ cell nuclei of *Drosophila* for a comparative analysis.
- **Study of Sex Chromatin (Barr Body)**
  - Slide preparation and study of the sex chromatin in human somatic tissues

Suggested Reading (editions to be informed by teacher)

1.	Essential Cell Biology	Alberts B *et al*.	Garland Publishing
2.	Molecular Biology of the Cell	Alberts B *et al*.	Garland Publishing
3.	The Eukaryotic Chromosome	Bostock CJ & Summer AT	Elsevier
4.	The Chromosome	Harrison HJS &Flavell RB	Bios
5.	Advanced Genetic Analysis	Hawley RS & Walker MY	Blackwell Publishing
5.	Structure & Function of Eukaryotic Chromosomes	HennigW	Springer

DSC-GEN-103
Experiential learning in Genetics - I

***Course Objective**: This course follows an experiential learning approach, promoting "learning by doing" as emphasized in the National Education Policy (NEP). Instead of performing separate experiments, students engage in hands-on activities that encourage curiosity and problem-solving. They learn to ask questions, design experiments, test different methods, analyse mistakes, troubleshoot issues, and repeat experiments when needed. Additionally, they develop skills in data collection, analysis, scientific writing, and presentation. This module helps students gain a deeper understanding of concepts while thinking and working like scientists. This paper has two units working with bacterial and plant systems, experiencing the power of genetical and biochemical approaches, respectively.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-GEN-103 Experiential Learning in Genetics- I	4	0	0	4	B.Sc in any branch of science	NA

Unit	Unit Name	
Practical		
I	Harnessing mutations – UV induced mutagenesis in E.coli	
II	From phenotype to function – characterizing mutants	
III	Enzymes from a seed: extraction and characterization of Acid phosphatase	
IV	From crude to pure: purification and evaluation of acid phosphatase	

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

- Think critically and solve problems – Ask scientific questions, design experiments, and troubleshoot challenges while working with UV mutagenesis and protein purification/characterisation
- Apply theory to practice – Use knowledge of microbial genetics and protein biochemistry in real experiments rather than just learning separate techniques.
- Analyse and interpret data – Collect, measure, and evaluate mutation frequencies, enzyme activity, and protein purification efficiency to draw meaningful conclusions.
- Improve scientific communication – Present findings clearly through reports, data visualization, and discussions, developing better communication skills.
- Adopt a research mindset – Learn to refine experiments, adapt methods, and explore new approaches, preparing for independent research in genetics and biochemistry.

Content (Practical) 120 hours

Introduction to Unit I and II: This module introduces students to UV mutagenesis in *E. coli*, providing hands-on experience in inducing, identifying, and analysing mutations. It allows students to connect different concepts from microbial genetics, metabolic regulation, and molecular biology with practical applications, giving them a holistic understanding. Through mutant screening, biochemical assays, and data analysis, students will develop key skills in experimental design, troubleshooting, and interpretation, preparing them for advanced genetic studies.

I. Harnessing mutations – UV induced mutagenesis in E.coli

- **Preparation of E. coli culture**:
  Grow wild-type bacterial culture to exponential phase for UV exposure
- **UV Mutagenesis protocol:**
  Expose bacterial culture to calibrated UV doses to induce random mutations
- **Recovery and plating on different media:**
  Plate treated cultures on media designed to screen for biochemical mutants—e.g., inability to metabolize lactose (MacConkey agar), auxotrophs (minimal media lacking specific amino acids), or altered pH indicators for acid/base production
- **Mutant screening and selection:**
  Identify mutants based on changes in colony colour, growth patterns, or response to biochemical indicators (e.g., enzyme-substrate colour shifts)

II. From phenotype to function – characterizing mutants

- **Enzyme assays (Optional Extension)**:
  Perform basic enzyme activity assays (e.g., β-galactosidase) to assess functional consequences of mutations
- **Quantification and analysis**:
  Calculate mutation frequency, assess phenotypic ratios, and interpret data to predict affected pathways or genes
- **Confirmation and characterization:**
  Re-test selected mutants to confirm stability of biochemical phenotype and rule out false positives
- **Discussion and Troubleshooting:**
- Collate data, analyse experimental challenges and variability, present data and discuss implications of findings, and reflect on how mutations reveal insights into biochemical systems.

Introduction to Unit III and IV: This project offers a structured approach to biochemical experimentation, integrating techniques into a cohesive workflow rather than treating them as isolated tasks. Focusing on the extraction, enzymatic characterization, purification, and analysis of acid phosphatase from moong dal sprouts, it equips students with hands-on experience in protein handling, enzyme kinetics, and purification strategies, deepening their understanding of core biochemical principles.

III. Enzymes from a seed: extraction and characterization of Acid phosphatase

- **Buffer systems and pH optimization:**
  Prepare acetate buffer (pH 5.0) to apply concepts of Henderson-Hasselbach equations taught to them in theory classes and used to maintain enzyme stability
  Plot titration curves for acetic acid and sodium dihydrogen phosphate (NaH_2PO_4) to understand workings of buffer systems
- **Enzyme extraction and activity assay:**
  Extract acid phosphatase from moong dal sprouts
  Determine the molar extinction coefficient of p-nitrophenol (PNP), the product generated from enzymatic activity measurements
  Assay acid phosphatase activity using PNPP as substrate and calculate its specific activity
- **Protein estimation and enzyme kinetics**
  Estimate total protein content
  Study the effect of varying substrate concentration on acid phosphatase activity
  Generate a Michaelis-Menten curve and determine Km and Vmax values

IV. From crude to pure: purification and evaluation of acid phosphatase

- **Protein purification**
  Isolate lysosomes from moong dal extracts using differential centrifugation and observe the enrichment of Acid Phosphatase
- **Data collation, analysis, interpretation and presentation**
  Compare Acid Phosphatase enzyme activity in crude vs. purified fractions.
  Calculate purification fold and enzyme yield.
  Discuss experimental challenges, errors, and possible improvements.

DSE-GEN-104
Molecular Biology

***Course Objective**: From a geneticist's point of view, the understanding of informational molecules, such as DNA, RNA, and proteins is central as they provide information on life and its processes. This paper deals with the structural and informational molecules, and their role in information transfer. This paper will focus on basic processes of copying, restructuring, readout and decoding of genetic information both in prokaryotes and eukaryotes with emphasis on discussions of seminal experiments and discoveries. Detailed mechanisms of each process will be discussed with components of machinery, factors and steps involved*.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-104 Molecular Biology	**4**	**3**	**1**	**0**	**B.Sc in any branch of science**	**NA**

Unit	Unit Name	
Theory		
I	DNA-discovery, forms and topology	
II	DNA Replication, Recombination and Repair	
III	Transcription	
IV	Translation	
Tutorials		
	Various modalities as given below	

Course Outcome: On completing 'Molecular Biology' the students would have:

- Understood DNA topology, replication mechanisms, recombination, and repair processes, along with their roles in genomic stability and disease.
- Learnt RNA and transcription and developed an understanding about RNA types, transcription mechanisms in prokaryotes and eukaryotes, gene regulation, and post-transcriptional modifications.
- Gained insights into translation and protein processing by analyzing concepts of genetic code, translation mechanisms, ribosome function, and post-translational modifications essential for protein synthesis
- Gained confidence in analyzing data from classical and contemporary research papers on these concepts

Content (Theory)

I. DNA -discovery, forms and topology 3 hours

- Tracing the path-breaking discoveries and seminal experiments on the road to identification of genetic material and its function (1869-1953)
- DNA structure and forms; Difference between RNA and DNA; Stability; Function of A, B and Z type
- DNA topology, domain organization in prokaryotes and eukaryotes
- Negative and Positive supercoiling, Types and function of Topoisomerases
- DNA conformation and complexity

II. DNA Replication, Recombination and Repair 20 hours

- Origin of replications : Structure, sequence, types in various organisms, Licensing and firing, methods of identifying origin of replication
- Assembly and function of the Replisome : Models of replication, molecular composition, mechanism, directionality & error rate
- Overcoming the end replication problem: Telomeres, telomerases and complexes
- Regulation of DNA replication
- Syncing with cell cycle, Kinase mediated regulation of DNA replication, negative and positive regulation of DNA replication in prokaryotes and eukaryotes
- Types of DNA damage
- Molecular Mechanisms of different types of DNA repair in prokaryotes and eukaryotes
- Recombination : Types, formation and resolution of recombinants in Homologous, non-homologous end-joining (NHEJ), recombinational repair, meiotic recombination
- Recombination events in biology and experimental systems
- Genomic instability and diseases associated with faulty repair and recombination

III. Transcription (in prokaryotes and eukaryotes) 12 hours

- Types of RNA, role of RNA in information transfer, Ribozymes, RNA world
- Transcription in Bacteria; RNA polymerase structure, Promoter structure, initiation, elongation and termination
- Transcription in eukaryotes; Multiple forms of eukaryotic RNA polymerases, promoters, enhancers and silencers
- Transcription factors & activators; DNA binding motifs, independence of the domains of activators
- Post-transcriptional events
- Other RNA processing events such as *trans*-splicing, RNA editing

IV. Translation (in prokaryotes and eukaryotes) 10 hours

- Mechanism of translation; Initiation, elongation, termination
    - Aberrant termination, use of stop codons to insert unusual amino acids
- The genetic code- nonoverlapping codons, no gaps in the code, breaking the code, unusual base pairs between codon and anticodon, codon usage
- tRNA structure, recognition of tRNA by aminoacyl-tRNA synthetase, proofreading and editing by aminoacyl-tRNA synthetase
- Ribosome: composition, structure and assembly

- Posttranslational; Folding of nascent proteins, Release of ribosomes from mRNA, Covalent modification

Content (Tutorial) 15 hours

- Addressing **Individual queries** on class concepts
- Discussing **research papers** on seminal work in the field exemplified by the following
    - Meselson M, Stahl FW. The replication of DNA in Escherichia coli (1958)
    - Watson, J., Crick, F. Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid. (1953)
    - Gros F., Hiatt H., Gilbert W., Kurland C.G., Risebrough R.W. and Watson J.D., Unstable Ribonucleic Acid Revealed by Pulse Labelling of *Escherichia coli* (1961).
    - Brenner S., Jacob F. and Meselson M, An Unstable Intermediate Carrying Information from Genes to Ribosomes for Protein Synthesis, (1961).
- Discussing **relevant video content** exemplified by
    - "Photograph 51" -a play by Anna Ziegler (https://youtu.be/H7BgQTpL7x4?si=c--iZzQy-KJ0UpUh)
    - The Structural History of RNA Polymerase Transcription Machinery - Nobel Laureate Dr. Roger Kornberg (https://www.youtube.com/watch?v=XkJfo0yJtqI)
- Performing **Class exercises** such as
    - generating right handed and left handed DNA molecules with mimics to understanding and record changes in linking number
- **Analysing results** of research papers as quiz based class discussion such as Identification of origin of replication; isolation of the components of transcription and translation machinery and others
- **Discussion** on use of radioactivity and its aftermath on scientists; precautions
- Exploring **digital resources** for understanding scope of experimental model systems such as
    - Jackson Laboratory with Cre-lox mice- discussion and video(https://youtu.be/ibNmCZqzmoo)

Suggested Reading

1.	Molecular Biology of the Cell	Alberts B et al	Garland Science
2.	Molecular Biology of the Gene	Watson J. D. et al	C S H L Press
3.	Genes X	Krebs, J. E et al	Jones & Bartlett Publishers
4.	Cell and Molecular Biology: Concepts and Experiments	Karp G.	Wiley
5.	The Cell: A Molecular Approach	Cooper G. M	Sinauer Associates
6.	Related papers as shared in class		

DSE-GEN-105
Cell Biology

Course Objective: *The course is geared to impart a basic understanding of cell structure and organization, bioenergetics, transport of proteins and RNA to and fro in eukaryotic organelles, checks and balances during stress, signal transduction, crosstalk between basic processes and cell cycle regulation, regulated protein destruction and basics on programmed cell death. Some of these will be discussed as a part of off-lecture series, demonstrations and discussions listed under tutorial.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-105 Cell Biology	4	3	1	0	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Cell structure and Organization	
II	Cellular energetics and Trafficking	
III	Cell cycle regulation & checkpoints	
IV	Cell signalling & cellular proteolysis	
Tutorials		
	Various modalities as given below	

Course Outcome: On completing 'Cell Biology' the students would have:

- Developed a thorough understanding of cell Structure and organization by learnings on cell architecture, organelles, and membrane dynamics.
- Learnt about cellular processes and regulation including energy production and cell cycle control.
- Acquired knowledge on biomolecular trafficking with insights on the mechanisms of protein and mRNA transport, protein sorting via the secretory pathway, endocytosis, and the regulation of cholesterol homeostasis.
- Gained insights into signalling and proteolysis wherein cell signaling, checkpoints, and protein degradation mechanisms would be covered

Content (Theory)

I. Cell structure and Organization 8 hours

- Protein structure, Plasma membrane; Fluid mosaic model
- Nuclear organization
- Information compartment- ER, Golgi, Mitochondria, Chloroplast, Cytoskeleton

II. Cellular Energetics and Trafficking 15 hours

- Energy rich compounds, ATP synthesis, thermodynamics of cellular reaction
- Protein and mRNA transport to and from nucleus
- Protein transport into ER and Mitochondria
- Protein sorting via secretory pathway
- Endocytosis
- Unfolded protein response;
- Cholesterol homeostasis- cellular transport, regulation of biosynthetic genes.

III. Cell cycle regulation & checkpoints 11 hours

- Overview of the cell cycle, cell cycle control system
- Role of cyclins and cyclin-dependent protein kinases (Cdks)
- Cdk phosphorylation and dephosphorylation,
- Cdk inhibitors
- Checkpoints and cellular responses

IV. Cell signaling & cellular proteolysis 11 hours

- Basic elements of cell signaling systems, Signal molecules and their receptors
- Signal transduction by G protein-coupled receptors, G protein cycle
- Role of intracellular messengers
- Protein-tyrosine phosphorylation as a mechanism for Signal transduction
- The cAMP-PKA pathway
- The Ras-MAP Kinase pathway
- Crosstalk among different signaling pathways
- Programmed cell death, Ubiquitin pathway, Proteosomes

Content (Tutorial) 15 hours

- Addressing **Individual queries** on class concepts
- Discussing **research papers** on seminal work in the field exemplified by the following:
  - Simon SM, Blobel G. A protein-conducting channel in the endoplasmic reticulum. Cell. 1991 May 3;65(3):371-80.
  - Walter P, Blobel G. Purification of a membrane-associated protein complex required for protein translocation across the endoplasmic reticulum. Proc Natl Acad Sci U S A. 1980 Dec;77(12):7112-6.
- Discussing **relevant video** content exemplified by
  - Günter Blobel's work on protein trafficking (https://www.nobelprize.org/prizes/medicine/1999/blobel/lecture/)
  - Paul Nurse's work on cell cycle regulation (https://www.nobelprize.org/prizes/medicine/2001/nurse/lecture/)
  - Dictyostelium Chemotaxis towards cAMP (https://youtu.be/lFx73Wq2QSQ?si=n5Ck7O7NTf-K_I_A)
- Discussing foundational experiments in class discussion such as:

- Heterokaryon experiments for diffusible regulatory molecules during cell cycle
- Identification of receptor for a particular signal
- Historical background for nitric oxide (NO) as a gaseous signal
- Genetic analysis to isolate cyclin partner for Cdk
- Effect of MPF activity on early and late mitotic processes
- Regulated protein degradation for survival

Suggested readings

1.	Molecular Cell Biology	Lodish H*et al.*	W. H. Freeman
2.	The World of the Cell	Becker WM *et al.*	Benjamin Cummings
3.	Biochemical Calculation	Seigel IH	Wiley
4.	Cell and Molecular Biology: Concepts and Experiments	Karp G.	Wiley
5.	Molecular Biology of the Cell	Bruce Alberts *et al.*	Garland

DSE-GEN-106
Enzymes and Metabolism

Course Objective: *Life on this earth has evolved through a set of simple biochemical reactions, which has subsequently given rise to specific cell types. Biochemistry and metabolic pathways are fundamental to life, influencing energy production, nutrient metabolism, and overall health. This course explores enzymatic function, inhibition, and regulation emphasizing on key biochemical pathways such as glycolysis, the TCA cycle, and oxidative phosphorylation, among others. The integral role in daily life—from diet and exercise to disease prevention and health maintenance, some of which will be discussed as a part of off-lecture series and discussions listed under tutorial.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-106 Enzymes and Metabolism	4	3	1	0	B.Sc in any branch of science	NA

Unit	Unit Name	
Theory		
I	Enzyme: Structure, types, kinetics with examples	
II	Carbohydrate metabolism	
III	Lipid and Protein metabolism	
IV	Nutrition and Metabolic diseases	
Tutorial		
	Various modalities as given below	

Course Outcome: On completing 'Enzymology & Metabolism ' the students would have:

- Analysed enzyme function and metabolism and understood the role of enzymes as biocatalysts, their mechanisms, specificity, kinetics, and regulatory processes, including inhibition and allosteric control.
- Learnt about an integration of biomolecule processing and energy metabolism particularly how macronutrients (carbohydrates, lipids, and proteins) are metabolized and utilized
- exploring key pathways such as glycolysis, the TCA cycle, oxidative phosphorylation, and lipid metabolism, along with their hormonal regulation.
- Gained insights into metabolic Disorders and health Implications such as metabolic diseases like diabetes and obesity, inborn errors of metabolism, and the impact of nutrition and metabolic states (e.g., exercise, starvation) on overall health.

Content (Theory)

I. Enzymes 10 hours

- Biocatalysts : why do they exist in nature? ; Properties of an enzyme ; Mechanism of a catalytic reaction; Specificity and kinetics of a reaction
- Inhibition of enzyme activity- Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive inhibitors
- Regulation of enzyme activity; Allosteric enzymes

II. Carbohydrate metabolism 14 hours

- Chemical bonds
- Redox reactions
- Types of Glucose Transporters and their specific actions
- Metabolism of carbohydrates
- Glycolysis, rate-limiting steps, regulation of glycolysis
- TCA cycle, role of acetyl-CoA & malonyl-CoA
- Oxidative phosphorylation, shuttle systems and Electron transport chain
- Hormonal Regulation of carbohydrate metabolism – Glycogenolysis, Glycogenesis and gluconeogenesis
- Warburg's effect in cancer

III. Lipid and protein metabolism 16 hours

- Catabolism of proteins
- Synthesis of non-essential amino acids and polypeptide chain
- Break down (lipolysis) : beta oxidation in mitochondria
- Synthesis (lipogenesis): structure and function of multi-enzyme complex Fatty acid Synthase
- Ketone body breakdown and synthesis
- Cholesterol synthesis

IV. Nutrition and Metabolic Diseases 5 hours

- Digestion and Uptake of Biomolecules
- Source of the building block matters! Evolving concepts on health
- Role of organs in metabolism
- State of rest, exercise and starvation – an overview
- Nutrition and gut microbiome; learnings from ayurveda and Charak Samhita
- Diabetes, Obesity, Cancer, Inborn errors of metabolism

Content (Tutorials) 15 hours

- Addressing **Individual queries** on class concepts
- Discussing **seminal work** in the field using Nobel prize lectures exemplified by the following
    - The engineer Francis H. Arnold who won the Nobel prize in Chemistry 2018 for her work on directed evolution of enzymes (https://youtu.be/6hOZ5e0g9Uo?si=i702AivmmR6IxY1W).

- Discovery of insulin lecture by Prof Ronald Kahn (https://youtu.be/W9YlXLN-wGU?si=SOW9vIA1z4ZzWaLB)

- **Performing Class exercises** such as
  - Calculation and recording of GTPase enzymatic activity i.e. hydrolysis of GTP to GDP
  - Calculation of Equilibrium dissociation constants for GTPase for GDP and GTP)
- **Analysing results of research papers** as quiz based class discussion such as
  - Lin B, Covalle KL, Maddock JR. 1999. The Caulobacter crescentus CgtA Protein Displays Unusual Guanine Nucleotide Binding and Exchange Properties. J Bacteriol 181:. (https://doi.org/10.1128/jb.181.18.5825-5832.1999)
  - Röder PV, Geillinger KE, Zietek TS, Thorens B, Koepsell H, Daniel H. The role of SGLT1 and GLUT2 in intestinal glucose transport and sensing. PLoS One. 2014 Feb 26;9(2):e89977.
- **Discussions** on use of knowledge on metabolism with examples from
  - Michael Phelps - physical training and endurance of athletes; 1000 calories and cold thermogenesis
  - Anna Hazare – effects of starvation
  - Weight loss and gain – sustaining diets
- **Exploring digital resources** for understanding scope of experimental model systems such as
  - Generation of a mighty-mouse - Hanson RW, Hakimi P. Born to run; the story of the PEPCK-Cmus mouse. Biochimie. 2008 Jun;90(6):838-42. & Supermouse official video by Case Western University (https://youtu.be/4PXC_mctsgY?si=_dzXn3A1_O-iLm2u)

Suggested readings

1.	Principles of Biochemistry	Lehninger*et al.*	W. H.Freeman
2.	Biochemistry	Devlin TM	Wiley-Liss
3.	Biochemistry	Berg JM, TymoczkoJL&Stryer LT	W. H.Freeman
4.	Biochemical Calculation	Seigel IH	Wiley
5.	Harper’s Biochemistry	Kennelly PH et al	McGraw Hill

GE-GEN-110
Genetics in Crop Improvement

***Course Objective**: Students will understand the basic concepts of crop improvement and how germplasm sources along with conventional and modern crop improvement methods can help achieve goals of food security.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-GEN-110 Genetics In Crop Improvement	4	3	1	0	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Introduction	
II	Sources of germplasm for breeding	
III	Conventional methods for crop improvement	
IV	Modern methods and application of crop improvement	
Tutorial		
	Various modalities as given below	

Course Outcome: On completing 'Genetics in Crop Improvement' the students would have:

- Gained insights into crop Improvement and breeding strategies and understood the fundamentals, history, and methods of crop improvement, including conventional breeding techniques for self- and cross-pollinated plants.
- Analyzed modern genetic approaches such as molecular breeding, marker-assisted selection, genome-wide studies, and advanced techniques like genomic selection and speed breeding.
- Developed an understanding of genetic transformation and biosafety and explored transgenic traits in crops, their applications, and the biosafety concerns associated with genetic modifications.
- Been enthused through invigorating discussion to take up research in crop improvement

Content (Theory)

I. Introduction 5 hours
- History, Scope and Basic concepts

II. Sources of germplasm for breeding 4 hours
- concept of gene pools and wild crop relative

III. Conventional methods for crop improvement 12 hours
- breeding for self vs cross pollinated
- recurrent selection
- backcross breeding

IV. Modern methods and applications of crop improvement 24 hours
- Molecular genetic breeding - Marker assisted breeding for important traits (Case study)
- Genome Wide Association Study (GWAS)
- Genomic selection
- Speed breeding

Content (Tutorial) 15 hours

- **Addressing individual queries** on class concepts
- **Discussing research papers** on seminal work in the field exemplified by the following
  - Shull GH (1909) A pure-line method in corn breeding. Journal of Heredity 1:51-58.
  - Borlaug NE (1970) The Green Revolution: Peace and Humanity. https://repository.cimmyt.org/entities/publication/73b44ad5-1fc1-4188-a413-0e68ddab5f60
  - Schell J, Van Montagu M (1977) The Ti-plasmid of *Agrobacterium tumefaciens*, a natural vector for the introduction of nif genes in plants? Basic Life Sciences 9:159-79.
  - Tanksley SD, McCouch SR (1997) Seed banks and molecular maps: unlocking genetic potential from the wild. Science 277(5329):1063-6.
  - Ashikari M, Sakakibara H, Lin S, Yamamoto T, Takashi T, Nishimura A, Angeles ER, Qian Q, Kitano H, Matsuoka M (2005) Cytokinin oxidase regulates rice grain production. Science 309(5735):741-5.
  - Ravindran S (2012) Barbara McClintock and the discovery of jumping genes. Proc Natl Acad Sci U S A. 109(50):20198-9.
- **Discussing relevant video** content exemplified by
  - "Norman Borlaug & The Green Revolution" - A brief overview of Borlaug's work and its impact on global agriculture (https://www.youtube.com/watch?v=Lg9-HTtgFOk)
  - "Gene Editing and CRISPR in Agriculture" - A TED Talk by Jennifer Doudna (https://www.youtube.com/watch?v=TdBAHexVYzc)
  - "Marker-Assisted Selection in Plant Breeding" - An overview of MAS, including examples of successful applications in crop improvement (https://www.youtube.com/watch?v=NdaUqGBHuD4 & https://www.youtube.com/watch?v=Vie33tMyX74)

- "Genetically Modified Crops and Their Impact" - Discussion on transgenic crop development, biosafety protocols, and societal implications (https://www.youtube.com/watch?v=jYjvJyEMHZ4 & https://www.youtube.com/watch?v=0OdQVB-akww)

- **Performing class exercises** such as
  - Simulating Marker-Assisted Selection (MAS) using real-world genetic data.
  - Designing a genetic map for drought tolerance using hypothetical QTL data.
  - Constructing a physical map for stress-responsive genes.
- **Analysing results of research papers** as quiz-based class discussions such as 'Identification of candidate genes for stress tolerance'
- **Discussion** on use of gene editing techniques in crop improvement; ethical considerations and biosafety protocols
- **Exploring digital resources** for understanding scope of experimental model systems such as
  - Mendel's seminar contributions (https://gregormendel200.org/gregor-mendel-2/his-life/)
  - Virtual Tour of IRRI - Exploring Rice Genetic Resources (https://www.irri.org)
  - Interactive Plant Breeding Platform (https://www.plantbreedingplatform.org)
  - Svalbard Global Seed Vault (https://www.croptrust.org/work/svalbard-global-seed-vault/)
- **Visiting different plant growth facilities** to give students a real time experience

Suggested Reading

1.	Principle of Crop improvement	Simmonds NW & Smart J	Blackwell Science
2.	Research papers for case studies		

SBC-GEN-111

Statistical Analysis in Biology

Course Objective: *Much of genetic analysis is based on quantitative data and therefore statistical techniques are used extensively. Data analysis requires an individual to firstly choose an appropriate test among the gamut of tools available and then have the skill to apply it. Therefore in this hybrid mode of learning, students will be first equipped with conceptual understanding of the principles of using these statistical tools. This will be followed hands-on technical learning based upon the FOSSEE (Free/Libre and Open-Source Software for Education) project which promotes the use of FLOSS tools in academia and research [FOSSEE Project - National Mission on Education through Information and Communication Technology (ICT), Ministry of Education (MoE), Government of India}. Though most of the teaching will follow a hybrid mode, the course has been structured into separate theory and practical components to meet syllabus requirements.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SBC-GEN-111 Statistical Analysis In Biology	2	1	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	
Theory		
I	Descriptive statistics and software	
II	Hypothesis testing, Correlation and Regression	
Practical		
I	Statistics using JASP	
II	Statistics using R	

Course Outcome: On completing 'Statistical Analysis in Biology' the students would have:

- Learnt which Statistical Methods to apply when given a biological question and dataset.
- Understood fundamental statistical concepts, experimental design, data visualization, significance testing, regression, and ANOVA.
- Gained experience in Computational and Multivariate Analysis and used R for data analysis, exploring correlations, PCA, and clustering techniques for genetic data interpretation.

Content (Theory)

I. Descriptive statistics and Software 4 hours

- Basic statistics
  - Samples and populations
  - experimental design,
  - data analysis, graphs
  - average
  - coefficient distributions (chi-square, binomial, poisson and normal)
- Introduction to R-package and JASP

II. Hypothesis testing, correlation and regression 11 hours

- Tests of statistical significance : t-test, z-test, F-test, U-test and others;
- Regression and Correlation : Pearson vs. Spearman correlation
- Analysis of Variance (ANOVA)
- Introducing Multivariate Analysis
- Principal Component Analysis (PCA) for high- dimensional genetic data
- Cluster analysis and classification techniques in genetics

Content (Practical)

Designed in a hybrid mode to blend theory, virtual learning with hands-on experience

I. Statistics using JASP 15 hours

This topic includes biological data analysis using JASP software. The datasets/library for JASP is available on the Open Science Framework (OSF) as well as GitHub repository.

- Descriptive statistics and data visualization
- Exploring data integrity – Detection of outliers and Testing for assumptions (Normality and Homoscedasticity)
- Hypothesis Testing (T-test, binomial test, Multinomial test, Comparing two or more than groups)
- Correlation and Regression
- Non-parametric tests (Spearman's rank correlation and Kruskal-Wallis – Non-parametric ANOVA)

II. Statistics using R 15 hours

The principal aim is to provide a step-by-step guide on the use of R statistical language to carry out statistical analysis and techniques widely used in life, chemical and physical sciences

- Descriptive Statistics and Tabulation
- Introduction to Graphical Analysis
- Hypothesis Testing
- Creating an interactive R Notebook/R Markdown document with code chunks and embedded output

Suggested Reading

1.	Biostatistics	Danial WW	Wiley
2.	Statistical Methods in Biology	Bailey NTJ	Cambridge Univ. Press

COURSE DETAILS

ALL PAPERS OFFERED IN SEMESTER 2 OF THE 2Y-PG

DSC-GEN-201
Regulation of Gene Expression

***Course Objective**: This course explores gene regulation across prokaryotic and eukaryotic systems, from basic mechanisms in bacteria to complex networks in multicellular organisms. It examines how gene expression is controlled at various levels, linking theory with real-world examples from development, disease, and therapy. Units I and II lay the foundation by connecting bacterial and eukaryotic regulation, while Units III focuses on epigenetic control in development and disease. Unit IV integrates these concepts, applying regulatory network insights to human diseases for a comprehensive understanding of gene regulation.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-GEN-201 Regulation Of Gene Expression	4	3	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	
Theory		
I	Concepts and Strategies in Gene Regulation: *lessons from bacteria and yeast*	
II	Gene Regulation in Eukaryotes: *Complexity in Multicellular Systems*	
III	A. Epigenetics: *Beyond the Genetic Code*	
	B. Events in Development and Disease: *Biological Consequences*	
IV	Genes Gone Rogue: *Disruption of Regulatory Networks in Disease*	
Practical		
I	Analysing gene regulation in *E. coli* using lac operon as a model	
II	Studying Gene-environment interaction	

Course Outcome: On completing 'Regulation of Gene Expression' the students would have:

- Gained a comprehensive understanding of gene regulation mechanisms wherein gene regulation at transcriptional, post-transcriptional, translational, and post-translational levels in prokaryotes and eukaryotes would be explored, integrating theory with experiments.
- Analysed the role of epigenetics in development and disease with details on epigenetic mechanisms like DNA methylation, histone modifications, and chromatin remodeling, linking them to gene expression and disease.
- Develop the ability to investigate and analyse mechanisms of gene regulation and expression at molecular, cellular, and organismal levels, including gene-environment interactions and epigenetic modifications.

Content (Theory)

I. Concepts and Strategies in Gene Regulation: *lessons from bacteria and yeast* 10 hours

- *Recap* – The process of information flow
- *Regulatory Mechanisms Across Levels:*
  - Overview of transcriptional, post-transcriptional, translational, and post-translational regulation.
  - Experimental strategies for analysing gene regulation across different levels.
  - Positive and negative regulators: Building inducible and repressible systems.
- *Lessons from Prokaryotic Systems:*
  - Jacob and Monod's Seminal Model
  - Comparative analysis of regulation of lactose, tryptophan, and arabinose operons
  - λ Phage: Genetic switch governing lysis and lysogeny.
  - Global regulatory systems: e.g. Role of sigma factors in bacterial gene regulation.
- *Regulatory Insights from Yeast:*
  - The GAL1 system in *Saccharomyces cerevisiae*: Eukaryotic parallels to bacterial models.
- *Connecting Prokaryotic and Eukaryotic Concepts:*
  - Drawing parallels between prokaryotic regulatory strategies and eukaryotic gene control.

II. Gene Regulation in Eukaryotes: *Complexity in Multicellular Systems* 10 hours

- Signal Perception:
  - Recap of cell signalling pathways
  - Parallels in bacterial systems
- Transcriptional, Post-Transcriptional and Translational Regulation
  - at constitutive, inducible, and tissue-specific promoters
  - by alternative splicing, RNA editing, mRNA stability
  - Translational regulation: control at initiation, codon usage, and efficiency.
  - Post-translational modifications and their role in fine-tuning gene expression.
- Control by small RNAs, including miRNAs and siRNAs
- Connecting Prokaryotic and Eukaryotic Concepts
  - Drawing parallels between prokaryotic regulatory strategies and eukaryotic gene control.

III. Epigenetics 10 hours

A. *Beyond the Genetic Code*

- Epigenetic Mechanisms and Pathways
  - Overview of epigenetic regulation: Concepts and biological significance.
  - Chemical modifications: DNA methylation and histone modification in chromatin structure & tools for their detection
- Chromatin Remodelling and DNA-Binding Proteins
  - Role of Polycomb and Trithorax group proteins
  - Chromatin remodeling – Histone variants and Families of remodelers

B. Events in Development and Disease: *Biological Consequences*

- Epigenetic events across organisms

- Genomic imprinting, X chromosome inactivation and transgenerational inheritance in mammals.
- Vernalization in plants: Epigenetic response to environmental cues.
- miRNAs in cell fate determination in *Caenorhabditis elegans*.
- Heterochromatin and mating type switching in *Saccharomyces cerevisiae*.
- Cellular memory and homeotic transformations in development across species.

C. Epigenetics in Stem Cell Reprogramming and Disease Biology

Cellular reprogramming and their potential in regenerative medicine.

- Application of epigenetic techniques in various biological systems with a focus on disease models and developmental biology.

IV. Genes Gone Rogue: Disruption of Regulatory Networks in Disease 5 hours

- Acquiring and analysing gene regulatory networks using examples from cancer, neurodegenerative diseases, and immune disorders.
- Epigenetic imprinting defects in human diseases.
- Targeting gene regulation in disease treatment: Epigenetic drugs, RNA therapies, and CRISPR-based interventions.

Content (Practical)

I. Analysing gene regulation in *E. coli* using lac operon as a model 16 hours

- Induction kinetics: comparative study between IPTG and lactose
- Expression of lac operon in the presence of different carbon sources
- Expression of lac operon in mutants generated in semester I (DSC-GEN-103)
- ***From basics to application (using any one example)***
  Using *lacZ* gene from *E. coli* to study cell type-specific promoter activity in *Dictyostelium* - making transformants, histochemical staining during development, comparing expression in wild type and mutants
- The UAS-GAL4 system from yeast to direct tissue specific expression in *Drosophila*

II. Studying Gene-environment interaction 14 hours

- Evaluating change in transcript expression of a gene in cancer cell-line under chemical/hypoxic/starvation (mimicking tumour microenvironment) stress using RT-PCR
- Investigating whether observed changes in gene expression are due to alterations in promoter methylation using methyl-specific PCR

Suggested Reading

1.	Genes and Signals	Mark Ptashne& Alexander Gann	CSHL Press
2.	A Genetic Switch	Mark Ptashne	CSHL Press
3.	Gene Regulation	David S.Latchmann	Chapman & Hall
4.	The *lac* operon	Benno Muller-Hill	Walter de Gruyter
5.	Genes	Benjamin Lewin	Prentice Hall
6.	Molecular Cell Biology	Lodish H *et al.*	W.H Freeman
7.	Molecular Biology of the Cell	Alberts B *et al.*	Garland Science
8.	Epigenetics	David AllisC	CSHL Press
9.	Classic and seminal papers in gene regulation		
10.	Research and review papers in epigenetics		

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DSC-GEN-202
Recombinant DNA Technology

Course Objective: *Recombinant DNA technology is a set of molecular techniques for localization, isolation, alteration and study of DNA segments or genes. Commonly known as genetic engineering it encompasses various ways to analyze, alter and recombine virtually any DNA sequences. Parting away from the classical gene-phenotype relationship, this technology provides information through direct reading of the nucleotide and/or protein sequences. This paper provides the details of various approaches, techniques and tools used as well as their application in the generation of commercial products of myriad usage (biotechnology).*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-GEN-202 Recombinant DNA Technology	4	3	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	
Theory		
I	Methods and of DNA, RNA and protein analysis & Applications of recombinant DNA technology in biology and medicine	
II	Gene cloning and identification	
III	Expression Analysis -Transcripts	
IV	Protein expression, engineering and interactions	
Practical		
I	Handling small volumes and dilutions	
II	Restriction digestion, ligation and resolution	

Course Outcome: On completing '**Recombinant DNA Technology**', the students would have:

- Learned key methods for DNA, RNA, and protein analysis, including electrophoresis, blotting techniques, gene cloning, and genome sequencing
- Explored expression analysis techniques such as PCR, transcriptome analysis, protein expression systems, and methods for studying protein interactions.
- Examined the applications of recombinant DNA technology in biology and medicine, including gene editing tools like CRISPR, ZFN, and TALENs.
- Been equipped with essential laboratory skills required to successfully carry out the subsequent project module.

Content (Theory)

I. Methods of DNA, RNA and protein analysis & Applications of recombinant DNA technology in biology 9 hours

- Electrophoretic techniques: agarose and polyacrylamide gel electrophoresis, native, SDS, and 2-D PAGE
- Blotting techniques – Southern, northern, and western blots; Preparation of probes; RFLP analysis, DNA fingerprinting and its application.
- Gene editing technologies: Cre-Lox, ZFN, TALENs, CRISPR/Cas9, HDR.

II. Gene cloning and identification 13 hours

- Basics of cloning- Restriction and DNA modifying enzymes; Isolation and purification of nucleic acids; cloning methods; Cloning vectors – plasmids, phages, lambda vectors, phagemids, cosmids, fosmids, PAC, BAC and YAC; Selection and screening of clones.
- Construction of DNA libraries- Genomic and cDNA libraries; Screening of genomic and expression libraries.
- Gene identification- Subtractive hybridization, chromosome walking and jumping.
- Genome sequencing- DNA sequencing by Maxam and Gilbert method, Sanger's method, whole genome shotgun sequencing, next generation sequencing; Genome annotation: an overview

III. Expression Analysis 10 hours

- Polymerase Chain Reaction (PCR)- Concept of PCR, Primer designing, various kinds of PCR- Nested, Multiplex, Stem-loop and inverse PCR, , Real-Time PCR, Digital/Droplets PCR, Ligation Chain Reaction; Applications of PCR; EST analysis, Promoter analysis; Mapping transcriptional start sites
- Analysis of gene expression: Northern blotting, Reverse transcription(RT) PCR, quantitative RT-PCR
- Transcriptome analysis – cDNA- and oligo arrays; Serial Analysis of Gene Expression (SAGE).

IV. Protein expression, engineering and interactions 13 hours

- Expression of recombinant proteins: Expression and tagging of recombinant proteins in *E. coli*, Other expression systems
- Protein engineering- Insertion and deletion mutagenesis, site-directed mutagenesis
- Proteome analysis: MALDI, protein arrays and their applications
- Analysis of protein-DNA and protein-protein interactions, Reverse Two-Hybrid Systems, gel retardation assay, Dnase-I footprinting, Yeast two and three-hybrids assay
- ChIP on chip assay
- Split and reverse hybrids
- Co-immunoprecipitations; Phage display

Content (Practical)

I. Handling small volumes and dilutions 8 hours

- Handling microvolumes: use of micropipettors and determining their accuracy by the gravimetric method.
- Preparation of dilution of given DNA (lambda DNA) sample and measure the absorbance at 260 nm to check the accuracy of dilution.
- Quantitating DNA: Absorbance of microvolumes; visual inspection on agarose gel using a dilution series of DNA samples of known concentration (e.g. lambda DNA).

II. **Restriction digestion, ligation and resolution** 22 hours

- Digesting a commercially available DNA sample (e.g. lambda DNA) with different enzymes, varying incubation time and enzyme units.
- Setting up ligation of digested lambda DNA and observing ligation by gel electrophoresis.
- Agarose gel electrophoresis: Making gels of different percentages (0.8, 1.0, and 1.5) and resolving fragments of different sizes (e.g. 1 Kb and 100 bp DNA ladders); plotting migration distance versus size to understand the concept of differential migration on agarose gel.
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Suggested Reading

1.	Gene Cloning and DNA Analysis: An Introduction	Brown TA	Blackwell Publications
2.	Gene Cloning and Manipulation	Howe C	CambridgeUniversity Press
3.	Principles of Gene Manipulation and Genomics	Primrose SB&Twyman RM	Blackwell Publications
4.	Principles of Gene Manipulation	Primrose SB Twyman RM & Old RW	WileyBlackwell
5.	Molecular Cloning: A Laboratory Manual (3- Volume Set)	Sambrook J *et al.*	CSHL Press
6.	Calculations for Molecular Biology and Biotechnology	Stephenson FH	Academic Press

DSC-GEN-203
Experiential learning in Genetics – II

Course Objective: *This project-based module aims to give students a complete and connected understanding of how to clone and express a gene of interest (GOI) in E. coli. Instead of learning individual techniques in isolation, students will experience how these methods come together in a real research-like setting. Building on their earlier priming on working with DNA, students will now apply and deepen their understanding through hands-on work. As they move through the project, they will not only plan and execute experiments but also learn and refine key recombinant DNA techniques as part of the process. The emphasis is on thinking through the workflow, dealing with experimental setbacks, and finding ways to troubleshoot and improve. The module encourages curiosity, collaboration, and creative problem-solving—helping students grow into confident, independent learners in the lab.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-GEN-203 Experiential Learning In Genetics- II	4	0	0	4	B.Sc in any branch of science	NA

Unit	Unit Name	
Practical		
I	Planning the journey- from gene selection to cloning strategy	
II	Constructing the vehicle- from PCR product to recombinant plasmid	
III	Revving the engine – induction and expression of recombinant protein	
IV	Proof and purity – Verification and optional purification of protein	

Course Outcome: By the end of this module, students will be able to:

- Design and execute a recombinant DNA workflow for cloning and expressing a gene of interest in *E. coli*
- Apply and refine key recombinant DNA techniques as part of an integrated project rather than isolated protocols

- Analyse and troubleshoot experimental results, learning from failures and modifying strategies accordingly
- Demonstrate scientific thinking and collaborative problem-solving in a research-like laboratory setting

Content (Practical) 120 hours

Objective: To clone a gene of interest (GOI) into an *E. coli* expression system, express a His-tagged recombinant protein, and analyse it using SDS-PAGE and Western blotting. The envisaged work flow is as follows:

Note:
The following unit-wise workflow exemplifies the processes that are envisaged to be covered in a seamless fashion. Variations in detail and methodology may occur based on specific project goals, organism of origin, available resources, or experimental choices made by students and instructors. This is a general guide to the typical steps involved.

I. Planning the journey- from gene selection to cloning strategy

- **Select a Gene of Interest (GOI)**
  Identify a biologically relevant, preferably intron-less gene from an organism such as *Drosophila*, *E. coli*, or human. Retrieve the sequence from a public database and define the coding region to be cloned.
- **Design the cloning strategy**
  Choose an appropriate expression vector (e.g., pET28a, pGEX). Select restriction enzyme sites preferably for directional cloning, plan for placement of tags (e.g., His-tag), and include translational signals like Shine-Dalgarno or Kozak sequences if necessary.
- **Isolation of genomic DNA**
  Analyse the yield and quality by gel electrophoresis, absorbance and ease with which it is digested.
- **Primer design & PCR amplification**
  Design primers with flanking restriction sites and tag sequences if needed. Perform PCR with optimized conditions (annealing temperature, Mg^{2+} concentration, extension time), and purify the amplified product

II. Constructing the vehicle- from PCR product to recombinant plasmid

- **Prepare insert and vector and create recombinants**
  Digest of the PCR product (is needed) and vector with selected enzymes, purify by gel elution, dephosphorylation and ligation, optimizing the insert-to-vector ratio and reaction conditions.
- **Transformation into competent *E. coli***
  Make competent *E. coli* cells for transformation, test transformation efficiency. Transform recombinant molecule and select for recombinants using alpha-complementation.
- **Screen for positive clones**

Screen colonies using colony PCR or restriction digestion of plasmid mini-preps to confirm the presence and correct orientation (is applicable) of the insert. Sequence to check correctness of the insert. While sequencing happens, students may proceed for the next steps using available recombinant clones.

III. Revving the engine – induction and expression of recombinant protein

- **Protein expression and analysis by SDS PAGE.**

  Optimize induction by varying concentrations of IPTG, time and temperature of induction to improve yield and solubility. Harvest and lyse induced cells using lysozyme and sonication. Run cell lysates on SDS-PAGE and stain with Coomassie Blue to assess protein expression and approximate size.

IV. Proof and purity – Verification and optional purification of protein

- **Western Blotting**

  Confirm the correctness of the expressed protein using antibodies against His-tag.
- **Purification of the protein (optional)**

  Purify the protein by affinity chromatography

DSE-GEN-204
Developmental Biology

Course Objective: *This course offers a comprehensive exploration of the molecular, cellular, and evolutionary mechanisms that drive the transformation of a single cell into a fully developed organism. By drawing on insights from diverse model organisms—including animals, plants, and unicellular systems—students will delve into fundamental concepts such as cell fate determination, morphogenesis, organogenesis, and regeneration. The course is inspired by Scott F. Gilbert's Developmental Biology, blending classical concepts with modern research developments.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-204 Developmental Biology	**4**	**3**	**1**	**0**	**B.Sc in any branch of science**	**NA**

Unit	Unit Name	
Theory		
I	Core Concepts of Developmental Biology	
II	Gametogenesis and Fertilization	
III	Early Development, axis formation, organogenesis in animals	
IV	Pattern formation in plants	
Tutorial		
	Various modalities as given below	

Course Outcome: On completing 'Development Biology,' students would have:

- Developed a comprehensive insight into the basics of developmental biology with molecular, cellular, and evolutionary mechanisms guiding the transformation of a single cell into a fully developed organism across various model systems, would be gained.
- Analysed key developmental processes in animals and plants by examining cell fate determination, morphogenesis, organogenesis, and regeneration, comparing unique developmental strategies in both plant and animal systems.
- Evaluated evolutionary and genetic influences on development by exploring the role of gene regulation, environmental interactions, and evolutionary principles in shaping developmental patterns and organismal diversity.

Contents (Theory)

I. **Core Concepts of Developmental Biology** 11 hours

- The cycle of life – life cycle of animal and flowering plants
- Overview of animal and plant development
- Importance of model organisms in developmental research
- Basic approaches to observe development
- Experimental approaches – 'Find it, Loose it, Move it'
- Basic concepts on how cells attain fate - Specification, induction, competence, determination, and differentiation
- Morphogen gradients and their role in pattern formation
- Cell-to-cell communication
- Gene regulatory networks and developmental decision-making
- Comparison between plant and animal developmental patterns
- Achieving multicellularity : division versus aggregation (*Dictyostelium*)
- Stem cells
- Introduction to evo-devo

II. **Gametogenesis and Fertilization** 11 hours

- Gametogenesis in plants and animals
- External fertilization in sea urchin
- Internal fertilization in mammals
- Fertilization in angiosperm plants

III. **Early Development, axis formation, organogenesis in animals** 10 hours

- A comparative analysis of early developmental processes and axis formation across different model organisms, including *C. elegans*, Drosophila, sea urchins, amphibians, birds, and mammals highlighting
  - Initiation of development and cleavage – exploring distinct patterns and mechanisms
  - Gastrulation and its outcomes - from classical experimental studies to modern molecular insights, highlighting the formation of germ layers and their developmental fates.
  - Axis Specification (Anterior-Posterior and Dorsal-Ventral) – a detailed analysis genetic and molecular mechanisms with emphasis on identifying key genes that regulate axis formation and determine cell fates.
- Formation of vulva in *C. elegans*
- Formation of tetrapod limb
- Regeneration

IV. **Pattern formation in plants** 13 hours

- Salient features of plant development, comparison between plant and animal development pattern
- Understanding plant development through examples –
  - Polarity determination during plant development
  - Regulation of transition to flowering,

- The ABCDE model of flower development in Arabidopsis and its variations.

Contents (Tutorial) 15 hours

- Addressing **individual queries** on class concepts
- Screen different videos on developmental biology which will help initiate discussions and help students attain a better perspective of the subject. Some examples are
    - **Developmental Biology Tutorials by Barresi Lab**
      A series of video tutorials covering key concepts in developmental biology.
      https://www.science.smith.edu/barresilab/developmental-biology-tutorials/
    - iBIOLOGY videos e.g.
        - Collaborating to find developmental genes
        - Control of embryonic axis formation in Drosophila involving Gurken
        - Cytoenemes: signalling at a distance
    - Videos from the Company of Biologists e.g.
      The Fascinating World of Developmental Biology
      https://www.youtube.com/watch?v=avrmIs3vPUQ
    - Videos showing experimental strategies to study developmental biology
- Classroom demonstration of observing chick development- window preparation
- Visit to institutes like IGIB and NII to experience the use of model systems of developmental like the zebra fish and C. elegans

Suggested Reading

1.	Developmental Biology	Scott F. Gilbert	Sinauer Associates, Inc.
2.	Principles of Development	Lewis Wolpert.	Oxford University Press

DSE-GEN-205
Immunology & Immunogenetics

Course Objective: *The course provides a comprehensive overview of basic concepts of immune system, mechanism of T and B cell mediated immunity and the humoral response including the complement system. Generation of peripheral and central tolerance and topics of clinical relevance, such as autoimmunity, tumour immunology, congenital and acquired immunodeficiencies, transplantation immunology, and immunotherapy are covered. All the topics are studied through lectures and an in-depth review of selected articles.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-205 Immunology & Immunogenetics	4	3	1	0	B.Sc In Any Branch Of Science	Na

Unit	Unit Name	
Theory		
I	Discoveries and overview of the immune system	
II	Innate Immune response	
III	Organization and diversity of immunoglobulin genes	
IV	The adaptive immune response	
Tutorial		
	Various modalities as given below	

Course Outcome: On completing 'Immunology & Immunogenetics', students would have

- Acquired an overview of types of immunity including the historical development of immunology, immune organs, and cell differentiation. Concepts of pattern recognition receptors, the complement system, inflammation, and key cellular responses like phagocytosis and neutrophil activity would be clear to them
- Covered adaptive immunity and antigen recognition particularly humoral and cell-mediated immunity, cytokines, antigen presentation by MHC molecules, and antigen recognition by BCRs, TCRs, and Fc receptors.
- Understood immune development and disorders including immunoglobulin gene organization, VDJ recombination, class switching, T and B cell development, and tolerance. The course concludes with immune-related diseases, including autoimmunity, hypersensitivity, and immunodeficiencies

Contents (Theory)

I. Discoveries and overview of the immune system 8 hours

- Historical development and seminal discoveries of immunology
- Immune cells – haematopoiesis, fate determination of myeloid and lymphoid progenitor cells
- Organs of the immune system

II. Innate Immune response 10 hours

- comparative immunology (lower order to vertebrates)
- Pattern recognition– four family of receptors and their pathways
- **c**omplement pathway (Classical, Alternate and Lectin)
- Inflammation
- Response to a finger prick - Analyzing tumor, rubor, calor and dolor
- Phagocytosis
- Neutrophil migration and neutrophil extracellular traps

III. Organization and diversity of immunoglobulin genes 9 hours

- Antibody structure, types and domains
- Generating diversity through recombination, molecular mechanisms of the VDJ recombination
- The mechanisms and process of class switch recombination
- Stepping up the immune response – Somatic Hypermutation and Affinity Maturation

IV. Adaptive immune response 18 hours

- Humoral and cell mediated immune response
- Cytokines and chemokines
- Antigen recognition and presentation
- Recognition by different cell-types
- Major Histocompatibility complex (MHC) genes and their organization
- MHC restricted cell types and T-cell receptors
- Antigen presentation by MHC class I and class II
- Receptors engaged in antigen recognition – FcR, BCR and TCR
- Antigen antibody interaction
- Molecular and cellular pathway of T cell development
- T cell maturation, types of T cells and their functions
- Central and peripheral tolerance
- Molecular and cellular pathway of B cell development, and maturation
- Activation of B and T cells
- Immunological Tolerance and Autoimmune diseases
- Allergy and hypersensitivity
  Transplantation immunology
- Immunodeficiencies

Content (Tutorial): 15 hours

- **Addressing individual queries** on class concepts
- **Discussing research papers** on seminal work in the field exemplified by the following

- The concept of variolation across ages - Boylston A. The origins of inoculation. J R Soc Med. 2012 doi: 10.1258/jrsm.2012.12k044.
- Humoral and cell-mediated immunity go hand-in-hand. Kaufmann, S. Immunology's foundation: the 100-year anniversary of the Nobel Prize to Paul Ehrlich and Elie Metchnikoff. (2008). https://doi.org/10.1038/ni0708-705
- Metchnikoff's stellar contribution.Jean-Marc Cavaillon & Sandra Legout. Centenary of the death of Elie Metchnikoff: a visionary and an outstanding team leader (2016) (https://www.sciencedirect.com/science/article/pii/S1286457916300697)

- **Discussing relevant video and reading content** exemplified by -
  - The controversies around Pastuer's work and records. Smith KA. Louis Pasteur, the father of immunology? Front Immunol. 2012 Apr 10;3:68. doi: 10.3389/fimmu.2012.00068.
  - Susumu Tonegawa – Nobel Laureate 1987 for his discovery of VDJ recombination (https://youtu.be/-rdcXmb8-jo?si=kMJo0419w3C_PWMr)
- **Analysing results of research papers** as quiz-based class discussions such as -
  - Learning from the groundbreaking work on antibody diversity. Hozumi N, Tonegawa S. Evidence for somatic rearrangement of immunoglobulin genes coding for variable and constant regions. (1976) (doi:10.1073/pnas.73.10.3628)
- **Discussions** on
  - Fetal-maternal health
  - Controversies around Louis Pasteur's work – a question on conduct & ethics
  - Gut microbiome & Indian knowledge system
  - Immunity while growing up and aging
- **Integrative learning** through examples such as
  - Possible outcomes when a bee stings and a thorn pricks?
- **Exploring digital resources** for understanding scope of immunological techniques such as:
  - Flow cytometry and Cell sorting (https://youtu.be/W1BFeiDwqnk?si=3Gw4ypX3Xo17IiZg)

Suggested Readings

1.	Kuby Immunology	Kindt TJ, Goldsby RA, Osborne BA, Kuby J	W H Freeman & Co
2.	Immunobiology: The immune system in health and disease	JanewayCA,Travers, P,Walport M, Shlomchik MJ	Garland Science Publishing
3.	Roitt's Essential Immunology	Delves PJ, Martin SJ, Burton DR, Roitt IM	Blackwell Publishing/Oxford Univ. Press

DSE-GEN-206
Mitochondrial Biology & Connection to Cell Physiology

Course Objective: *In the last decade, mitochondria have been recognized to be highly dynamic. Most undergraduate courses lack any relevant critical examination of various aspects of mitochondrial cell biology, which the course aims to do. Here in, we will deal with the mitochondrial genetic material organization in eukaryotes, mode of replication and cytoplasmic inheritance, aspects of process linked to connection with cellular metabolism, and energy production. We will also examine the signals and machinery regulating mitochondrial copy numbers and partitioning during cell division. Various unique features of mitochondrial gene expression will be delved into, in addition to diseases caused by disrupted mitochondrial activity*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-GEN-206 Mitochondrial Biology & Connection To Cell Physiology	4	3	1	0	B.Sc in any branch of science	NA

Unit	Unit Name	Hours
Theory		
I	Mitochondrial physiology and genome organization	
II	Mitochondrial dynamics	
III	Mitochondrial gene expression	
IV	Mitochondrial genetics and molecular medicine	
Tutorial		
	Various modalities as given below	

Course Outcome: On completing, 'Mitochondrial Biology & Connection to Cell Physiology' students would have:

- Understood the organization and function of the mitochondrial genome by exploring the dual nature of the mitochondrial proteome, its evolutionary links to bacteria, mechanisms of protein import and sorting, and the principles of non-Mendelian inheritance.
- Analysed mitochondrial physiology and dynamics by examining mitochondrial metabolic pathways, retrograde signalling, copy number control via fusion and fission, and quality control mechanisms, including mitophagy and transport to daughter cells.
- Evaluated the role of mitochondrial gene expression and genetics in disease and the impact of mutations in mitochondrial and nuclear genomes on human diseases.

Contents (Theory)

I. **Mitochondrial physiology and genome organization** 15 hours
- Metabolic pathways touching mitochondria
- Mitochondrial output control by nuclear genome
- Mitochondrial retrograde signaling
- links to cellular life span
- Dual nature of mitochondrial proteome
- Evolutionary links to bacteria
- Mitochondrial protein import and sorting mechanism
- Non-mendelian transmission of mitochondrial genetic material

II. Mitochondrial dynamics 10 hours
- Mitochondrial copy number control via fusion and fission
- transport of mitochondria to daughter cells
- mitochondrial quality control
- mitophagy

III. **Mitochondrial gene expression** 10 hours
- unique features of transcription
- ribosome structure, and protein translation in mitochondria
- Transcriptional and translational control by nutrition- Amino acid starvation and TOR signaling, glucose repression and de-repression.

IV. Mitochondrial genetics and molecular medicine 10 hours
- Disease examples due to mutation in nuclear and mitochondrial genome.

Content (Tutorial) 15 hours

- **Addressing individual queries** on class concepts
- **Discussing research papers on seminal work** :
  - on discovering mitochondrial fusion and fission machinery. A few examples are here.
    - Fusion -Sesaki and Jenson (2001) https://doi.org/10.1083/jcb.152.6.1123
    - Morphology- Otsuga et al (1998)https://doi.org/10.1083/jcb.143.2.333
    - Fission-Mozdy, McCaffrey and Shaw (2000) https://doi.org/10.1083/jcb.151.2.367
  - on seminal work on discovering protein synthesis by ribosomes attached to the mitochondria. A few examples are here.
    - Biogenesis-Marc et al (2002) https://doi.org/10.1093/embo-reports/kvf025& Garcia et al (2010)https://doi.org/10.1038/embor.2010.17
  - on seminal work related to understanding the alternate translation system within the mitochondria with a special focus on the ribosome structure and translation initiation
    - Fox TD (2012) https://doi.org/10.1534/genetics.112.141267

- The following **videos** will be used to discuss the essential functioning of the mitochondria for a healthy cell.
  - https://www.ibiology.org/cell-biology/mitochondria-metabolism/
  - https://www.ibiology.org/cell-biology/mitochondrial-pyruvate-carrier/
  - https://www.ibiology.org/cell-biology/mitochondria/
  - https://www.ibiology.org/cell-biology/mitochondria/

Suggested Reading

1.	Classical and current Research Papers	Shared by the teacher	
2	Mitochondria	Douglas C. Wallace and Richard J. Youle	CSHL Press
3	Mitochondrial Biology: New Perspectives	Derek J. Chadwick (Editor), Jamie A. Goode (Editor)	By Novartis Foundation, John Wiley & Sons Inc
4	The Human Mitochondrial Genome: From Basic Biology to Disease	Giuseppe Gasparre and Anna Maria Porcelli	
5	Mitochondria and the Future of Medicine	Lee Know	Chelsea Green Publishing Co

GE-GEN-210

Genetics in Everyday Life: from DNA to Society

Course Objective:

This General Elective course introduces the basic principles of genetics, focusing on their relevance to everyday life, health, technology, and society, along with the ethical questions raised by emerging genetic technologies. It offers a broad understanding of how genetic concepts connect to real-world challenges, without getting into technical complexities. Designed for students from diverse academic backgrounds, the course uses real-world case studies, interactive debates, and accessible readings to help students explore key ideas and their societal impact, encouraging critical thinking and ethical reflections.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-GEN-210 Genetics In Everyday Life: From DNA To Society	4	3	1	0	B.Sc in any branch of science	NA

Unit	Unit Name	
Theory		
I	Introduction to Genetics	
II	Genetics in Health and Medicine	
III	Genetics in Society and Environment	
IV	Ethical, Legal, and Social Issues (ELSI) in Genetics	
Tutorial		
	Various modalities as given below	

Course Outcome: On completing 'Genetics in Everyday Life: From DNA to Society' the students would have :

- Understood genetic principles in everyday life by gaining a foundational understanding of genes, inheritance, and genetic diversity, exploring how genetics shaped traits, health, and interactions with the environment.
- Explored the role of genetics in health, society, and technology by analyzing real-world applications of genetics in medicine, agriculture, biodiversity, and forensic science, assessing the benefits and risks of genetic advancements like CRISPR, genetic testing, and GMOs
- Critically assessed ethical and social implications by engaging in discussions on ethical dilemmas, genetic privacy, and the societal impact of genetic technologies, developing an informed perspective on how genetics influenced public policies and everyday decisions.

Content (Theory)

I. **Introduction to Genetics** 12 hours
- Genes, genomes, and chromosomes
- The genetic basis of diversity: Mutations and variations
- Interaction of genes and environment to shape phenotypes
- How traits are passed down

II. **Genetics in Health and Medicine** 12 hours
- Genetics and human diseases
- Personalized medicine: How your DNA can influence drug response
- Genetic testing: Benefits, risks, and accessibility
- Gene therapy and CRISPR: Editing genes for better health

III. Genetics in Society and Environment 11 hours
- Genetically Modified Organisms (GMOs) and their impact on agriculture
- Genetics and biodiversity: Conservation and endangered species
- Forensic genetics: DNA fingerprinting in crime and identity verification

IV. **Ethical, Legal, and Social Issues (ELSI) in Genetics** 11 hours
- Ethical dilemmas: Designer babies, cloning, and eugenics
- Genetic privacy: Who owns your genetic information?
- Public perception of genetics: Misinformation and media portrayal

Content (Tutorial) 15 hours

Case Studies for Discussion and Analysis – indicative examples

To enhance understanding and foster critical thinking, the course will incorporate real-world case studies across various units. These examples highlight the practical relevance of genetic concepts and their ethical, societal, and scientific implications.

- **Genetics in Health and Medicine**

  -The Angelina Jolie Case: BRCA1/BRCA2 Genetic Testing

  An exploration of hereditary breast and ovarian cancer risk assessment, genetic testing, and its implications for preventive healthcare.

  Sickle Cell Anaemia and Malaria Resistance

  A case demonstrating how a single genetic mutation can confer disease resistance while also causing hereditary disorders, illustrating the complexity of natural selection at the genetic level

- **Genetics in Society and Environment**
  - *Transgenic Mustard: The Indian story:* Focusing on the science and the socio-political controversies surrounding genetically modified organisms (GMOs).
  - *DNA Fingerprinting and The Innocence Project:* An examination of forensic genetics' role in exonerating wrongfully convicted individuals, highlighting the power and ethical considerations of DNA evidence in the legal system.

- **Ethical, Legal, and Social Issues (ELSI) in Genetics**

- *CRISPR Gene Editing: The Case of He Jiankui* - A critical analysis of the first reported gene-edited human embryos, exploring the ethical violations, global responses, and potential consequences of germline editing.
- *Eugenics: A Historical Misuse of Genetics*- An investigation into the dark history of eugenics, focusing on policies in Nazi Germany and forced sterilizations in the United States, while reflecting on the importance of ethical boundaries in modern genetic research.

  These case studies will be supported by group discussions, interactive debates, and reflective assignments to help students connect theoretical knowledge with real- world applications and ethical dilemmas.

- **Discussion on Books (Popular Science and Introductory Texts) – indicative examples**

Students can be encouraged to read any of the popular science books for discussion

- Siddhartha Mukherjee – *The Gene: An Intimate History*
  A comprehensive history of genetics, tracing the journey from Mendel's early experiments to modern advancements like CRISPR.
- Jennifer Doudna & Samuel Sternberg – *A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution*
  An insightful look into CRISPR gene-editing technology, co-authored by one of its pioneers, along with a discussion on its ethical implications.
- Richard Dawkins – *The Selfish Gene*
  A foundational book explaining gene-centric evolution and natural selection, written in an engaging and accessible style.
- Matt Ridley – *Genome: The Autobiography of a Species in 23 Chapters*
  A chapter-by-chapter exploration of the human genome, providing a deep yet accessible understanding of how our genes shape us.
- Mark Lynas – *Seeds of Science: Why We Got It So Wrong on GMOs*
  A critical examination of the controversies surrounding genetically modified organisms (GMOs), written by an environmentalist who re-evaluated his stance based on scientific evidence.

SBC-GEN-211
Microscopy and Imaging

***Course Objective**: Microscopy and imaging are technical expertise areas, aligning perfectly with the NEP's emphasis on skill-based learning. By training students to operate imaging tools and analyse biological data, it equips them with practical, research-ready skills essential for careers in modern biology, biotechnology, and healthcare. Hands-on technical learning cannot be built without a strong theoretical understanding. This hybrid course thus blends theory with hands-on training to provide insights into different types of microscopy and related techniques. Students will explore the principles behind various imaging techniques while directly engaging with instruments to connect the principles with their usage. The aim is to build both knowledge and practical skills for using microscopy in biological research. Though most of the teaching will follow a hybrid mode, the course has been structured into separate theory and practical components to meet syllabus requirements.*

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SBC-GEN-211 Microscopy And Imaging	2	1	0	1	B.Sc in any branch of science	NA

Unit	Unit Name	
Theory		
I	Microscopy: Principles, types and application	
III	Microscopy-based techniques and applications	
Practical		
I	Microscopy: Principles and methods	
II	Microscopy-based techniques and applications	

Course Outcome: On completing 'Microscopy and Imaging', the students would have:

- Understood the theoretical principles of various microscopy techniques including light, fluorescence, confocal, electron, and advanced imaging methods, and their applications in biological research.
- Acquired hands-on skills in operating different types of microscopes and imaging systems, along with basic competencies in image acquisition, processing, and analysis.

Content (Theory)

I. Microscopy: principles, types and applications 10 hours

- Basic properties of light, light spectrum, image formation, fluorescence, and phosphorescence
- Resolution, numerical aperture, aberrations, and corrective measures
- Components in modern microscopes and types of objective lenses
- Bright-field Microscopy, Dark-field Microscopy, Phase-contrast Microscopy, Differential interference contrast (DIC) microscopy, Fluorescence Microscopy,
- Commonly used fluorophores and selection of fluorophore combinations for fluorochromes for colocalization studies
- Confocal & super-resolution Microscopy, Electron Microscopy (SEM and TEM), Atomic force microscopy, Cryogenic electron microscopy (cryo-EM).

II. Microscopy-based techniques and applications 5 hours

- Live Cell imaging, Fluorescence recovery after photobleaching (FRAP), Fluorescence Resonance Energy Transfer (FRET), Fluorescence Lifetime Imaging Microscopy (FLIM)
- Digital imaging, image processing, and analysis.

Content (Practical)

Designed in a hybrid mode to blend theory, virtual learning with hands-on experience

I. Microscopy: Principles and methods 20 hours

- A virtual tour of the history of development of microscopy
- Virtual module introducing the properties of light, image formation, and resolution using interactive simulations.
- Hands-on session to identify and understand the function of various components of modern microscopes.
- Demonstration of different types of objective lenses and their impact on magnification and resolution.
- Virtual demonstration on identifying and correcting common optical aberrations using alignment tools and calibration slides.
- In-lab training on bright-field, dark-field, and phase-contrast microscopy using biological specimens.
- Guided hands-on session in fluorescence microscopy: fluorophore selection, filter cube handling, and image capture.
- Confocal microscopy demonstration (live or recorded), including z-stack image acquisition and 3D reconstruction.
- Introduction to advanced imaging systems—SEM, TEM, AFM, Cryo-EM—through virtual lab tours or expert video lectures and visit to facilities

II. Microscopy-Based Techniques and Applications 10 hours

- Virtual module of live cell imaging, sample preparation and visit to facility for demonstration
- Demonstration and data analysis of advanced techniques such as FRAP, FRET, and FLIM using shared image datasets.
- Practical training in digital image processing using ImageJ/Fiji for tasks such as quantification, colocalization, and enhancement.

- Case studies and group discussions integrating microscopy-based techniques with real biological research problems.

Suggested Reading

1.	Adventures with a Microscope	Headstrom R	Dover Publications, USA
2.	Introduction to Optical Microscopy	Mertz J	Roberts & Company Publishers, USA
3.	Fundamentals of Light Microscopy and Electronic Imaging	Murphy DB	Wiley & Sons Publication, USA
4.	Basic Methods in Microscopy: Protocols and Concepts from Cells: A Laboratory Manual	Spector DL & Goldman RD	CSHL Press, USA
5.	Fluorescence Microscopy: From Principles to Biological Applications	Ulrich Kubitscheck	Wiley VCH
6.	Adventures with a Microscope	Headstrom R	Dover Publications, USA
7.	Handbook of Biological Confocal Microscopy	James Pawley	Springer-Verlag New York Inc
8.	Confocal Microscopy for Biologists	Alan R. Hibbs	Springer-Verlag New York
9.	Single-particle Cryo-EM of Biological Macromolecules	Glaeser et al.	Institute of Physics Publishing
10	https://www.microscope.healthcare.nikon.com/		
11	https://www.olympus-global.com/technology/museum/micro/		
12	https://www.zeiss.com/microscopy/en/about-us.html		
13	https://www.leica-microsystems.com/		
14	Relevant Review and Research Papers		

EC (1275) - 23.05.2025

Annexure-3

UNIVERSITY OF DELHI
MASTER OF SCIENCE (MICROBIOLOGY)
Syllabus of Sem 1 and Sem 2
based on
NEP-PGCF-2024

As approved in the meeting of 'Committee of Courses' held on 24th Feb 2025, in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on 17th March 2025, and meeting of 'Standing Committee' held on 02nd May 2025

PROGRAMME BROCHURE

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2025 and Executive Council on YYYY, 2025

I. About the Department

Historical Background of Department

The Department of Microbiology was established in 1984, initially functioning in the University's main campus at the Patel Chest Institute where classes for the M.Sc. Microbiology program were held. The M.Sc. program was initiated with the enrollment of five students each year. The current intake for this program is fifteen students each year.

The Department moved to the South Campus in 1986 and became affiliated with the Faculty of Interdisciplinary and Applied Sciences upon its establishment in 1988. The students who graduate from our Master's program take up positions in academia/industry or pursue higher studies. The Microbiology Department started the Ph.D. program as well in 1988. Since then, more than one hundred students have carried out their doctoral research work in the Department, and several of them now hold leadership positions in academia and industry.

Department Highlights

The Department is now well established, currently with seven faculty members. Extramural grants from DBT, DST, ICMR, CSIR, UGC, ICAR and DRDO, as well as intramural grants from the University of Delhi, have strengthened the Department's research. The Department has also been funded under the DST-FIST, UGC-SAP and DU-DST PURSE programs. Every faculty member has a well-equipped laboratory with the necessary instruments to carry out research. The departmental Central Instrumentation Facility houses several pieces of high-end equipment. More than six hundred research papers have been authored by faculty members of the Department in peer-reviewed journals of international repute. The achievements of the Department have been recognized in the form of several awards conferred on the Department's faculty and students.

About the Program

The M.Sc. Microbiology program offered by Delhi University is of two years' duration and is divided into four semesters. The various courses of the program are designed to include classroom teaching and lectures, laboratory work, project work, viva, seminars, and assignments.

Six categories of courses are being offered in this program: Department Specific Core (DSC) Courses, Department Specific Elective (DSE) Courses, Generic Elective (GE) courses (student may opt for any of the Generic Elective courses offered by any other Department of the Faculty of Interdisciplinary and Applied Sciences), Skill Enhancement Courses (SEC), Research methods/ tools/ writing courses, and Dissertation/ Problem-based Research work. The Core Courses and Discipline Specific Elective Courses are four-credit courses. The Generic Electives are also four-credit courses. The student is required to accumulate twenty-two credits each semester: a total of eighty-eight credits over four semesters to fulfill the requirements for a Master of Science degree in Microbiology (two-year program), and forty-four credits over two semesters to fulfill the requirements for a Master of Science degree in Microbiology (one-year program) .

About Post-Graduate Attributes

The curriculum is designed to train the students in basic and advanced areas of Microbiology, keeping in mind the latest advances in the field. Particular emphasis is laid on the practical aspects of the field. Students are taught how to plan experiments, perform them carefully, analyze the data accurately, and present qualitative and quantitative results. To enable them to develop speaking and presentation skills they are encouraged to deliver seminars on a wide range of topics covering the different areas of Microbiology. This also leads them to read about different themes and enhances their assimilation abilities. A major component of their course in Structure 2 and Structure 3 is a research project they work on in their final year. The student is guided in choosing a research problem, executing experiments related to it, collecting data and analyzing it, and presenting the results in the form of an oral presentation as well as a thesis. The student presents their research orally at the end of the final semester of the program, coupled with a viva-voce exam. This not only equips the student for a career in research/ industry, but also fosters self-confidence and self-reliance in the student as they learn to work and think independently. At the end of the program the student will be well-versed in essential microbiology as well as be familiar with the most recent advances in microbiology, and will have gained hands-on experience in microbiology, including fermentation technology and molecular biology techniques. The student will be able to design a short research problem, plan and execute experiments to investigate the problem, as well as analyze and present the results obtained both qualitatively and quantitatively. The student will be able to take up a suitable position in academia or industry, and be equipped to pursue a career in research if so desired.

Program Objectives (POs):

At the time of completion of the program the student will have developed extensive knowledge in various areas of Microbiology. Through the stimulus of scholarly progression and intellectual development the program aims to equip students with excellence in education and skills, thus enabling them to pursue a career of their choice. By cultivating talents and promoting all-round personality development through multi-dimensional education, a spirit of self-confidence and self-reliance will be infused in the student. The student will be instilled with values of professional ethics and be made ready to contribute to society as responsible individuals.

Program Specific Outcomes (PSOs):

At the end of the two-year program, the student will understand and be able to explain different branches of Microbiology such as Bacteriology and Virology. The student will be able to explain various applications of Microbiology such as Environmental Microbiology, Industrial Microbiology, Food Microbiology, and Microbial Pathogenicity. They will be able to design and execute experiments related to Basic Microbiology, Immunology, Molecular Biology, Recombinant DNA Technology, and Microbial Genetics, and will be able to execute a short research project incorporating techniques of Basic and Advanced Microbiology under supervision. The student will be equipped to take up a suitable position in academia or industry and pursue a career in research if desired.

About Program Structure

The M.Sc. Microbiology program is a two-year program divided into four semesters, or a one-year program divided into two semesters. A student has to accumulate twenty-two credits in each semester. Under the two-year M.Sc. program a student is required to complete eighty-eight credits for completion and award of M.Sc. degree, while under the one-year M.Sc. program a student is required to complete forty-four credits for completion and award of M.Sc. degree. The program structure is based on the Post Graduate Curricular Framework (PGCF) under New Education Policy (NEP)-2020.

Under PGCF, in the first year of the two-year program, the student is required to study mandatory Discipline Specific Core courses (three DSC in each semester) and a total of four / Discipline Specific Elective courses (two DSE in each Semester). In lieu of one DSE in each Semester, the student may choose to study a Generic Elective course offered by any other Department of FIAS. In addition, the student will also be required to study one mandatory Skill enhancement course (SEC) in each semester of the first year.

In the second year of the two-year program, the student will have an option to choose any one of the three structures: Structure 1 (PG with only coursework), Structure 2 (PG with coursework and research), or Structure 3 (PG with coursework and more emphasis/weightage on research). The details regarding these structures have been summarized in tabular form.

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. MICROBIOLOGY COURSE (NEP-PGCF)

First year (common in Program Structure 1, 2 and 3)

Semester-1

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-01: Bacteriology	3	1	0	4
DSC-02: Molecular Virology	3	1	0	4
DSC-03: Microbial Physiology and Metabolism	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-01: Immunology	3	1	0	4
DSE-02: Cell Biology	3	1	0	4
Generic Elective (GE) courses*				
GE-01: Essentials of Microbiology	3	0	1	4
Skill enhancement course (SEC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SEC-01: Basic Microbiological Techniques	0	2	0	2
Research Methods/ Tools/ Writing	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

* *(a student can opt for either two DSE courses, or one DSE with one GE)*

Semester-2

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-04: Environmental Microbiology	3	1	0	4
DSC-05: Industrial Microbiology	3	1	0	4
DSC-06: Microbial Pathogenicity	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-03: Molecular Biology	3	1	0	4
DSE-04: Plant Pathogen Interactions	3	1	0	4
Generic Elective (GE) courses*				
GE-02: Microbial Biotechnology	3	0	1	4
Skill enhancement course (SEC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SEC-02: Environmental, Industrial & Molecular Microbiology Techniques	0	2	0	2
Research Methods/ Tools/ Writing	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

* *(a student can opt for either two DSE courses, or one DSE with one GE)*

DISCIPLINE SPECIFIC CORE COURSE – DSC-01: BACTERIOLOGY

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-01: BACTERIOLOGY	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to introduce the students to the fundamentals of bacteriology.
- The students will gain knowledge about the structural and functional details of bacteria cells as well as archaea.
- The course will familiarize the students with bacterial cell division, genome organization and survival.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe the structural components of bacterial cells in detail, including the cell wall difference in gram-negative and gram-positive bacteria
- Students will be able to recall bacterial cell division and endospore formation
- Students will be able to evaluate the key features of some model archaeal organisms and differentiate them from eubacteria
- Students will be able to describe the salient features of the genome organization of several selected bacteria including extremophiles
- Students will be able to analyze quorum sensing and its significance in competence and pathogenesis

- **SYLLABUS OF DSC-01**

UNIT – I (15 hours)

Bacterial and Archaeal cell structure, Archaeal diversity and model organisms: Overview of bacterial cell organization: nucleoid, intracytoplasmic membranes and cell inclusions. Overview of Gram-negative and Gram-positive bacterial cell wall, outer membrane lipopolysaccharide (LPS). Detailed account of cell wall synthesis and its inhibitors. External cell surface structures: capsule, glycocalyx, slime layer and S-layer. Biogenesis and function of various cell structure appendages: flagella- structure, assembly and mechanism of movement; pili and fimbriae. Phylogenetic diversity and key features of different phyla. General characteristics of archaeal cell structure. A detailed account of model archaeal organisms: Methanococcus, Halobacterium, Pyrococcus and Sulfolobus

UNIT – II (12 hours)
Bacterial cell division, mode of reproduction, bacterial genome: Binary fission and other forms of reproduction in bacteria. Bacterial cell cycle. Bacterial Z ring : Assembly, maintenance and disassembly, chromosome segregation. Endospore structure and stages involved in endospore development in *Bacillus subtilis*. Timeline of genome sequencing, Genome organization of *E.coli* and salient features of genomes of *Deinococcus radiodurans*, *Azotobacter vinelandii*, *Buchnera sp*., *Agrobacterium tumefaciens* and *Epulopiscium sp*.

UNIT-III (10 hours)
Bacterial secretion system: Introduction. Sec secretion pathway, SecB secretion pathway, SRP pathway, Tat pathway. Protein secretion in Gram-negative bacteria: Sec dependent system (Type II, V, VIII, IX) Sec independent system (Type I, III, IV, VI). Protein secretion in Gram-positive bacteria: Type VII, Sec A2, Sortases and Type VII secretion systems.

UNIT-IV (8 hours)
Quorum sensing: Discovery, role as illustrated by bioluminescence (*Vibrio fischeri*, *Vibrio harveyi*), virulence (*Pseudomonas aeruginosa*, *Staphylococcus aureus*), competence and sporulation (*Bacillus subtilis*). Quorum quenching: impact and mechanism.

Practical component (30 hours)

1. Isolation of bacteria pure culture from soil.
2. Characterization of the bacteria by colony morphology, staining characteristics and biochemical characteristics.
3. Extraction of genomic DNA from the isolated bacteria
4. PCR amplification of the 16S rRNA gene using universal primers, analyzing the given 16srRNA sequences by BLAST PCR amplification of the 16S rRNA gene using universal primers, analyzing the given 16srRNA sequences by BLAST

Essential/recommended readings

Theory:

1. Fundamentals of Bacterial Physiology and Metabolism by Rani Gupta and Namita Gupta. Springer 2021.
2. Prescott's Microbiology by, J. Willey, K. Sandman, D. Wood. 12th edition. McGraw Hill Education. 2023.
3. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education. 2018.

Practicals:

1. Microbiology, A laboratory manual by James G. Cappuccino and Chad T. Welsh. 12th Edition. Pearson Education. 2019.
2. Laboratory Exercises in Microbiology by Nathan Rigel and Javier Izquierdo. 12th edition. Mc Graw Hill Education. 2022.

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

DISCIPLINE SPECIFIC CORE COURSE DSC– 02: MOLECULAR VIROLOGY

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-02: MOLECULAR VIROLOGY	4	3	0	1	B.Sc. in any branch of Life Science	None

Learning Objectives

The Learning Objectives of this course are as follows:

- The student will be able to develop understanding of molecular virology by examining common processes and principles in viruses to illustrate viral complexity and understand viral reproduction
- They will gain understanding of the molecular biology of viral reproduction and the interplay between viruses and their host organisms
- They will understand the strategies by which viruses spread within a host, and are maintained within populations.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the classification of viruses, tools for studying virus structure, process of virus attachment and entry, virus assembly and release
- Student will be able to recall steps in the replication of the genome of RNA viruses, retroviruses, and DNA viruses
- Student will be able to discuss steps in virus infection, transmission, patterns of infection, virus virulence, and host defense against virus infection.
- Student will be able to describe the methods of making virus vaccines and anti-viral drugs, drivers of virus evolution, and emerging viruses
- Student will be able to recall unusual infectious agents, virus mediated cellular transformation and oncogenesis, evasion strategies used by viruses, and learn to apply their knowledge to investigate virus outbreak

SYLLABUS OF DSC- 02

UNIT – I (13 hours)

Introduction to Virology, Virus Structure, Assembly, and Release: Common strategy of viruses, classification of viruses, the virus infection cycle, methods of studying virus infection, modified Koch's Postulates for viruses. Virus genome types: double-stranded DNA (dsDNA), gapped DNA genomes, single-stranded (ssDNA) genomes, double-stranded RNA (dsRNA), single-stranded RNA (ssRNA), (+) strand RNA, single-stranded (+) sense RNA with DNA intermediate, single-stranded RNA (-) sense, ambisense RNA genomes. Concept of metastability in the context of virus structures, different tools for studying viral structural biology. Helical symmetry in viruses, Icosahedral symmetry in viruses, Triangulation number, Quasi-equivalence. Virus attachment and entry, Initiation of infection, Affinity and Avidity between virus and its receptor, cellular receptor for viruses. Virus entry into the nucleus, virus disassembly, concentrating viral components for virus assembly, and how components get to the right place in the cell. How do viruses make sub-assemblies, sequential and concerted assembly? Viral genome packaging signals, packaging of segmented genome, acquisition of an envelope by viruses, and budding strategies.

UNIT – II (8 hours)

RNA directed RNA synthesis, Reverse Transcription and Integration, Translation, and genome replication of DNA viruses: Identification of RNA polymerase, how RNA synthesis occurs in viruses, Reverse transcriptase, retrovirus genome organization, steps of DNA synthesis in retroviruses. Regulation of translation in the virus infected cells. Basic rules of genome replication in DNA viruses, viral origins of DNA replication, virus coded polymerases. Generic steps in transcription, initiation, splicing, alternate splicing, promoter structure, steps in the regulation of transcription, enhancers, virus-coded transcriptional regulators, transcriptional cascade, and export of transcript from the nucleus.

UNIT – III (16 hours)

Virus Infections basics, virus-host interactions, Vaccines and anti-viral drugs, virus evolution and emerging viruses: Fundamental questions of viral pathogenesis, Virion defenses to hostile environment, viral spread, viremia, determinants of tissue tropism. Virus shedding, transmission of infection, host defense, innate immune response, virus virulence, identifying virulence genes. Toxic viral proteins, cellular virulence genes, immunopathology, systemic inflammatory response syndrome. Immune complexes, virus-induced auto-immunity, general pattern of infection. Inapparent acute infections, defense against the acute infection. Pathogenesis of Influenza, Polio, Measles, and Rotavirus. Persistent infections, and chronic and latent Infections. Concept of herd immunity, requirement of an effective anti-viral vaccine, different ways of making vaccine. Inactivated vaccines, subunit vaccines, live attenuated vaccines, how influenza vaccine and Polio vaccine were made, and polio eradication. Anti-viral drugs, search for anti-viral drugs, the path for drug discovery, mechanism-based screens, cell-based screen, and antiviral screening. Resistance to antiviral drugs. Main drivers of virus evolution, the quasi-species concept, error threshold, genetic bottlenecks, Muller ratchet, genetic shift and drift. Theories on the origin of the virus, evolution of new viruses, emerging viruses, factors that drive viral emergence, and evolving host-virus relationship.

UNIT – IV (8 hours)

Unusual Infectious Agents, viral-mediated transformation, evasion strategies, virus outbreaks: Viroids, origin of viroids, Satellites, Prions, Transmissible spongiform encephalopathy (TSE) caused by prions, Prion hypothesis, Prion species barrier. Virus-induced cancer by RNA viruses, Avian leucosis retroviruses, Proviral DNA sequences, Proto-oncogenes, DNA tumor Viruses, the link between DNA virus biology and transformation. Strategies for evasion, Translational regulation, Innate defense targets, Viral modulators of interferon, Autophagy, Apoptosis, Apoptotic pathway and viruses, Immune modulation, and Immune modulation strategies. Case study of health risks associated with a virus epidemic, the origin of outbreak, the spread, the intervention strategies, public health response.

Practical component (30 hours)

1. Handling, upkeep and calibration of micropipette for measuring small volumes.
2. Sterilization techniques and their application in the microbiology lab.
3. Working with a biosafety cabinet in a BSL2 lab
4. Culturing of eukaryotic cells of epithelial and lymphoid origins.
5. Counting and passaging of eukaryotic cells of epithelial and lymphoid origins.
6. Principles and techniques of freezing and thawing eukaryotic cells for long-term storage.

Essential/recommended readings

Theory:

1. Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses by S.J. Flint, L.W. Enquist, V.R. Racaniello, A.M. Skalka. 5th edition. ASM Press. 2020.
2. Introduction to Modern Virology by N. Dimmock, A. Easton, K. Leppard. 7th edition. Blackwell Publishing. 2016.
3. Basic Virology by Edward K. Wanger, M. Hewiett, D. Bloom, D. Camerini. 3rd edition. Blackwell Publishing. 2007.
4. Principles of Molecular Virology by A.J. Cann. 6th edition. Elsevier Academic Press. 2015.

Practicals:

1. Microbiology: A laboratory manual by JG Cappucino, C.T. Welsh. 11th edition. Pearson. 2017.

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

DISCIPLINE SPECIFIC CORE COURSE – DSC-03: MICROBIAL PHYSIOLOGY AND METABOLISM

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-03: MICROBIAL PHYSIOLOGY AND METABOLISM	4	3	0	1	B.Sc. in any branch of Life Science	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this paper is to develop a clear understanding of various aspects of microbial physiology.
- To understand diverse metabolic pathways in bacteria concerning its survival and propagation.
- To enable students to understand better courses taught later, such as Microbial Pathogenicity and biotechnology-based courses.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to interpret the data acquired from methods of measuring microbial growth and calculating growth kinetic parameters with an understanding of steady-state and continuous growth.
- Students will be able to define in-depth knowledge of primary, secondary, and group translocation transport systems existing in bacteria.
- Students will be able to describe the central metabolic pathways for carbon metabolism in bacteria and their regulation in diverse physiological conditions. This will allow students to apply the acquired knowledge for engineering the metabolic pathways for developing industrially useful strains.
- Students will be able to understand the inorganic and organic nitrogen assimilation, regulation and role of glutathione in cellular redox regulation.
- Students will be able to understand the details of lipid and nucleotide metabolism in *E. coli* and its regulation along with the biochemical basis of lipid accumulation in yeasts.
- Students will be able to describe bacteria's intracellular signaling in response to various nutritional and physiological stresses.

SYLLABUS OF DSC-03

UNIT – I (14 hours)
Growth and cell division: Measurement of growth, physiology, cell division, growth yields, growth kinetics, steady-state growth and continuous growth. **Solute Transport:** Introduction, simple and facilitated diffusion, kinetics, primary and secondary transport. Membrane transport proteins: porins and aquaporins, mechanosensitive channels, ABC transporter, group translocation PEP-PTS system. Catabolite repression, inducer exclusion and expulsion.

UNIT – II (08 hours)
Central Metabolic Pathways and Regulation: Glycolysis and its regulation, Gluconeogenesis, Pentose-Phosphate Pathway, Entner-Doudoroff Pathway, Citric Acid Cycle, alternate TCA, Glyoxylate Pathway and its regulation. Examples of pathway engineering of carbon metabolic pathways to develop valuable industrial strains.

UNIT – III (08 hours)
Nitrogen metabolism: Inorganic nitrogen assimilation- nitrate and ammonia assimilation, glutamate synthetase and its regulation. Outline of amino acid biosynthesis: using precursors from glycolytic pathway, from Citric Acid Cycle. Glutathione: distribution in bacteria, biosynthesis and role in redox regulation.

UNIT – IV (15 hours)
Metabolism of lipids and nucleotides: Biosynthesis and degradation of lipids and its regulation in *E. coli*, lipid accumulation in yeast. Purine and pyrimidine biosynthesis, deoxyribonucleotide synthesis, regulation of purine and pyrimidine biosynthesis, inhibitors of nucleotide biosynthesis. **Physiological Adaptation and Intracellular Signalling:** Introduction to two-component system. Response to physiological stress: aerobic-anaerobic shifts- Arc and Fnr system, osmotic homeostasis. Response to nutritional stress: phosphate supply- Pho regulon, and stringent response.

Practical Component (30 hours)

1. To determine the specific growth rate and doubling time of *E. coli* strain in different media.
2. To study the diauxic growth curve of *E. coli* strain in media containing glucose and lactose and perform β-galactosidase assay.
3. To study glucose uptake by *E. coli*.
4. To draw the titration curve of the amino acid (glycine) and determine its pI.
5. To draw the titration curve of acid and base.
6. To prepare a 1M Phosphate buffer solution for pH 7 using the Henderson-Hasselbach equation.
7. To prepare the standard curve of Glucose by using the DNSA method.
8. To separate amino acids/sugars using Thin Layer Chromatography (TLC).
9. To study spectral scanning to understand the UV absorption of protein due to aromatic amino acids.

Essential/recommended readings

Theory:

1. Biochemistry by Berg, J.M., Tymoczko, J.L., Gatto, G.J., and Stryer, L. 9th edition. W.H. Freeman and Company, UK. 2019.
2. Microbial Biochemistry by Cohen, G.N. 2nd edition. Springer, Germany. 2014.
3. Lippincott's Illustrated Reviews: Biochemistry by Ferrier, D.R. (editor). 6th edition. Lippincott Williams and Wilkins, USA. 2013.
4. Microbial Physiology by Moat, A.G., Foster, J.W. and Spector, M.P. 3rd edition. John Wiley & Sons, USA. 2002.
5. Lehninger Principles of Biochemistry by Nelson, D.L. and Cox, M.M. 7th edition. W.H. Freeman and Company, UK. 2017.
6. Understanding Enzymes by Palmer, T. and Horwood, E. 3rd edition. Wiley, UK. 1991.
7. Biochemical Calculations by Segel, I.H. 2nd edition. Wiley and Sons, UK. 2004.
8. The Physiology and Biochemistry of Prokaryotes by White, D., Drummond, J. and Fuqua, C. 4th edition. Oxford University Press, UK. 2011.
9. Biochemistry by Zubay, G.L. 4th edition. Brown Company, USA. 1999.
10. The Cell: A Molecular Approach by G.M. Cooper. 8th edition. Oxford University Press, UK. 2018.

Practicals:

1. A Cell Biology Manual by J. Francis. Kendall. Hunt Publishing Co, USA. 2022.
2. Practical Laboratory Manual- Cell Biology by A. Gupta, B.K. Sati. Lambert Academic Publishing, USA. 2019.
3. Cell Biology Practical Manual by R. Gupta, S. Makhija and R. Toteja. Prestige Publishers, India. 2018.
4. Laboratory Manual of Cell Biology by R. Majumdar, R. Sisodia. Prestige Publishers, India. 2018.
5. Essential Cell Biology Vol **1**: Cell Structure- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.
6. Essential Cell Biology Vol **2**: Cell Function- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.

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

DISCIPLINE SPECIFIC CORE COURSE – DSC-04: ENVIRONMENTAL MICROBIOLOGY

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-04: ENVIRONMENTAL MICROBIOLOGY	4	3	0	1	B.Sc. in any branch of Life Science	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The primary objective of this course is to introduce the basic concepts of environmental microbiology and the role of microorganisms in ecosystems.
- The students will learn about microbial diversity (in soil, water, and air).
- They will become familiar with the role of microorganisms in biogeochemical cycles and their importance in maintaining ecological stability.
- The students will explore microbial biodegradation and bioremediation processes and their use in pollution control.
- They will discover extremophiles, how they adapt, and their industrial applications.
- The students will gain knowledge on wastewater treatment and microbial-based sustainable environmental management.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe the diversity of soil, water, and air microorganisms.
- Students will be able to explain the role of microorganisms in biogeochemical cycling, including carbon, nitrogen, sulfur, and phosphorus cycles.
- Students will be able to evaluate the role of microbial biodegradation and bioremediation in environmental sustainability.
- Students will be able to examine the properties and adaptations of extremophiles and their biotechnological uses.
- Students will be able to describe wastewater treatment principles in various treatment types and the significance of microorganisms involved in different treatment processes.
- Students will be able to evaluate the effects of human behavior on microbial ecosystems and highlight microbial approaches to environmental conservation.

Syllabus of DSC-04

UNIT-I (14 hours)
Developments in Environmental Microbiology and Microbial Diversity: Development of microbial ecology and the emergence of environmental microbiology, significant applications of microbes in solving environmental pollution problems. Role of microorganisms in achieving Sustainable Development Goals (SDGs), including clean water, climate action, sustainable agriculture, and pollution control. Understanding microbial diversity in the environment by culture-dependent and culture-independent approaches, Analysis by FAME, measuring metabolic capabilities using BIOLOG, G+C analysis, slot-blot hybridization of community DNA, and fluorescent in situ hybridization of intact cells, metagenomic analysis of solid and aquatic sediments. Introduction to advanced omics technologies (metatranscriptomics, metabolomics) for microbial community analysis. Principles and applications of SAGs in studying unculturable microorganisms.

UNIT-II (15 hours)
Extremophiles and Environmental Microbial Applications: Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles. Biotechnological applications of the same. Exploration of extremophiles in space research and astrobiology. Soil and water microbiology: Importance of soil microorganisms, microbial antagonism, biofilms, and their biotechnological applications. Lignocellulolytic microorganisms, enzymes, and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles, (iv) biofuels, (v) animal feed production.

UNIT-III (8 hours)
Liquid and solid waste management: Treatment of sewage (primary, secondary, and tertiary treatments), treatment of industrial effluents (distillery, textile, pulp, and paper), methods to detect various pollutants (metals, sediments, toxins, and organic matters). Solid waste types, composting, landfill development, incineration methods, composting and sustainable agriculture, biogas production, plastic degrading microorganisms as a tool for bioremediation, and challenges in waste management.

UNIT-IV (8 hours)
Bioremediation and Emerging Pollutants: Petroleum hydrocarbons and pesticides, use of biosensors for their detection. Microbial enhanced oil recovery, bioleaching of copper, gold, and uranium, electronic waste management. Microbial approaches for PFAS (forever chemicals) degradation and other emerging pollutants.

Practical Component (30 hours):

1. Microbiological Quality of Water (MPN Method)
2. Detection of *E. coli* in Water
3. Detection of *Salmonella* in Water
4. Soil Sample Basic Properties (pH, water holding capacity, moisture content, and organic matter content)
5. Microbial Activity in Soil by CO_2 Evolution
6. Effect of Moisture and Organic Matter on Microbial Activity in Soil

7. Dehydrogenase Activity by Soil Microorganisms
8. FDA Hydrolysis to Determine Microbial Activity in Soil
9. Nitrate Reduction Activity by Soil Microorganisms

Suggested Readings:

Theory:

1. Microbial Ecology by R.M. Atlas, R. Bartha. 3rd edition. Benjamin Cummings Publishing Co, USA. 1993.
2. Environmental Microbiology by A.H. Varnam, M.G. Evans. Manson Publishing Ltd. 2000.
3. Environmental Microbiology edited by R. Mitchell, J-D Gu. 2nd edition. Wiley-Blackwell. 2009.
4. Environmental Microbiology by R. Maier, I. Pepper, C. Gerba. 2nd edition. Academic Press. 2009.
5. Environmental Microbiology: Principles and Applications by P.K. Jemba, Science Publishing Inc. 2004.
6. Lignocellulose Biotechnology: Future Prospects by R.C. Kuhad, A. Singh. I.K. International. 2007.
7. Environmental Microbiology of Aquatic & Waste Systems by N. Okafor. 1st edition, Springer, New York. 2011.
8. Microbial Bioremediation: Biochemical and Molecular Technologies by Shilpi Gupta. Springer. 2021.

Practical:

1. Manual of Environmental Microbiology edited by C.J. Hurst, R.L. Crawford, J.L. Garland, D.A. Lipson, A. L. Mills, L.D. Stetzenbach. 3rd edition. Blackwell Publishing. 2007.
2. Environmental Microbiology: A Laboratory Manual by C.J. Hurst. 2nd edition. American Society for Microbiology, 2016.

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

DISCIPLINE SPECIFIC CORE COURSE: DSC-05
INDUSTRIAL MICROBIOLOGY

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-05: INDUSTRIAL MICROBIOLOGY	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Science**	**None**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course aims to give students an overview of Industrial microbiology by studying the different processes involved in microbial product development.
- The goal of this course is to familiarize students with the various bottlenecks in technology development, from bench scale to product commercialization.
- They will gain proficiency in modifying microbial strains through metabolic engineering.
- Students will gain knowledge about the cost-effective production of biopharmaceuticals and recombinant therapeutics through bio-manufacturing.
- They will explore various types of equipment and their designs used in large-scale biomass processing and product recovery.
- They will acquire practical experience in various bulk recovery processes for microbial products.
- Students will acquire essential knowledge about different chromatography techniques and tools utilized in product refinement.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe various kinetic parameters of microbial growth.
- Students will understand microbial strain development and the design of media requirements for optimal growth.
- Students will comprehend the sterilization process during large-scale operations.
- Students will be able to distinguish between laboratory-scale and industrial-scale bioreactor design and operation.

- Students will be able to discuss the equipment and processes involved in microbial product recovery.
- Students will efficiently utilize various microorganisms to produce commercial enzymes and microbial products economically

Syllabus of DSC-05

UNIT – I (8 hours)

Introduction to industrial microbiology and Microbial growth kinetics: Introduction to Industrial microbiology, microbial products, and fermentation processes, sources of industrially important microorganisms, oxidation-reduction principle in fermentation, stoichiometric balance analysis of carbon and nitrogen in different biochemical reactions, biomanufacturing and biofoundry, BioE3 (Biotechnology for Economy, Environment and Employment) policy, Monod kinetics of microbial growth, growth and non-growth associated product formation, specific growth and product formation kinetics, mathematical modeling of microbial processes, open and closed systems, Batch cultivation, fed-batch cultivation, types of fed-batch cultures, feeding strategies for large scale biomass production in fed-batch (exponential, DOstat, pHstat), Continuous Stirred Tank Reactor (CSTR) operation, bioprocess optimization strategies

UNIT – II (11 hours)

Media optimization, designing of industrial strains and Sterilization operations: Media for microbial and animal cultures, designing of cost-effective media for industrial operations. Mathematical strategies for media optimization Role of microorganisms in industrial production processes, microbial cultures and preservation techniques, inoculum development, metabolic engineering, and flux analysis in microbial strain improvement, high throughput screening methods, the role of recombinant DNA technology in strain modification, **S**terilization techniques for different types of growth media, kinetics and mathematical modeling of sterilization processes, Arrhenius equation and role of Del factor in large-scale industrial sterilization processes, the effect of sterilization on media quality, biomass, and product yield coefficients, types of equipment and operation in batch, and continuous sterilization, filter and steam sterilization at industrial scale

UNIT – III (8 hours)

Designing different fermenters and instrumentation control parameters: Designing of laboratory and industrial scale fermenters, Cleaning in Place (CIP) and Sterilization in Place (SIP) operations, Basic components of a fermenter, fermenter construction materials, Glass and stainless steel fermenters, types of impellers, types of baffle and spargers, foam controller, types of fermenter; stirred tank, bubble column*, Airlift, hollow fibers, p*acked beds, fluidized beds, perfusion cultures, photo-bioreactors and animal cell culture bioreactor, Measurement of various control parameters in bioreactor like pH, dissolved oxygen, temperature, antifoam, PID control, *respiratory quotient,* oxygen mass transfer coefficient (KLa), effect of dissolved Oxygen on microbial processes, effect of foam and anti-foam on oxygen transfer,

UNIT – IV (18 hours)

Development and **Downstream processing of microbial products:** Development of heterologous expression platforms like bacteria, yeast, and mammalian cells, process optimization of recombinant biopharmaceuticals; industrial enzymes and food additives, therapeutic proteins, biosimilars, chimeric and humanized antibodies, antibody fragments, applications of enzyme immobilization and cell surface display technology, Development of nano-biocatalyst, Current Good Manufacturing Practice (CGMP) Batch Filtration, Stokes Law of batch filtration, batch and continuous centrifugation operations, Physical and chemical methods of microbial product recovery, Liquid Liquid Centrifugal Separator, chromatography techniques in product recovery (Affinity, Ion exchange, size exclusion, reverse phase, and hydrophobic interaction chromatography), cross-flow/tangential flow filtration, ultra-filtration, and reverse osmosis, drying (lyophilization and spray drying), Principle of Fast Protein Liquid chromatography (FPLC) and High-Performance Liquid chromatography (HPLC). Process economics of fermentation process, cost breakdown at various stages in the process development, industrial effluent treatment.

Practical Component (30 hours):

1. Preparation of competent yeast cells
2. Transformation of Yeast cells with recombinant plasmids for intracellular and extracellular of Green fluorescent protein (GFP) and red fluorescent protein (RFP)
3. *E. coli* expression studies using GFP and RFP as model protein
4. Isolation and Refolding of inclusion bodies produced in bacterial expression system
5. Recovery of microbial products using various physical and chemical methods.
6. Principle of cross-flow/tangential flow filtration strategy and recovery of recombinant Lipase from *Pichia* expression system
7. Designing strategies for microbial products purification using affinity Chromatography
8. Designing strategies for microbial products purification using Ion exchange chromatography.
9. Desalting of proteins using size exclusion chromatography
10. Purification of recombinant proteins using Fast Protein Liquid chromatography (FPLC)
11. Analysis of purified proteins using High-Performance Liquid chromatography (HPLC)

Suggested Readings:

1. Principles of Fermentation Technology by Peter Stanbury, Allan Whitaker, Stephen Hall Butterworth-Heinemann. 3rd edition. 2016.
2. Bioprocess Engineering: Basic Concepts by Michael L. Shuler and Fikret Kargi. 2nd Edition. Pearson Education India. 2015.
3. Modern Industrial Microbiology & Biotechnology by N. Okafer. CRC Press, USA. 2007.
4. Fermentation Microbiology and Biotechnology by El Mansi & Bryce. CRC Press. 2012.
5. Microbial Biotechnology: Fundamentals of Applied Microbiology by Alexander N. Glazer and Hiroshi Nikaido. 2nd edition. Cambridge University Press. 2007.
6. Pharmaceutical Biotechnology: Concepts and Applications by Gary Walsh. John Wiley & Sons Ltd. 2016.
7. Pharmaceutical Biotechnology: Fundamentals and Applications by Daan J. A. Crommelin, Robert D. Sindelar, and Bernd Meibohm. 4th Edition. Springer. 2013.

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DISCIPLINE SPECIFIC CORE COURSE: DSC–06: MICROBIAL PATHOGENICITY

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-06 MICROBIAL PATHOGENICITY	4	3	0	1	B.Sc. in any branch of Life Science	NONE

Learning Objectives:

- The objective of this course is to help the students understand various attributes that make the microbes pathogenic or disease-causing, the emergence of newer pathogens that are relevant to India and the various tools for their local or global spread.
- The students would also learn the mechanisms of resistance of bacteria to antibiotics and the role of newer vaccines in controlling infectious diseases.
- The course would also enable students to describe the molecular diagnostic methods and automated equipment that may be used to diagnose diseases caused by microorganisms.

Learning Outcomes:

Upon successful completion of the course:

- The student will be able to understand classical and molecular determinants of disease-causing microbes
- The student will be able to describe the characteristics of newer disease-causing bacteria and viruses
- The student will be able to study and critique the various molecular tools available to work on the molecular epidemiology of disease-causing microorganisms.
- The student will be able to study and evaluate mechanisms underlying the resistance of bacteria to antibiotics, the spread of resistance and the use of newer vaccines to control infectious diseases
- The student will be able to gather information as to how infectious diseases may be diagnosed using newer diagnostic tools and what automated equipment is available for use in diagnostic microbiology laboratories.

SYLLABUS OF DSC-06

UNIT – I (13 hours)

Classical view and Molecular microbial pathogenicity: Define pathogenicity and virulence; Quantitative measures of pathogenicity: minimal lethal dose (MLD), LD50, ID50, TCID50. Virulence determinants: colonization, toxins, enzymes and invasiveness. Facultative/ obligate intracellular pathogens. Molecular Koch's postulates, multiplicity of virulence determinants, coordinated regulation of virulence genes, and environmental regulation of virulence determinants by two-component signal transudation systems, antigenic variation; clonal and panmictic nature of microbial pathogens, type three secretion system (TTSS, T3SS), Role of biofilms and quorum sensing in microbial pathogenicity.

UNIT – II (20 hours)

Emerging pathogens and Molecular Epidemiology: Illustrate emerging and re-emerging pathogens using *V. cholerae* 0139, X-MDR *M. tuberculosis, Helicobacter pylori,* Enterohaemorrhagic *E. coli* (EHEC), *Cryptosporidium parvum*, Bird/swine flu, AIDS and dengue hemorrhagic fever, opportunistic fungal pathogens. Mechanisms of emergence of new pathogens: horizontal gene transfer (HGT) and pathogenicity islands (PAI). Objectives of microbial epidemiology. Biochemical and Immunological tools - biotyping, serotyping, phage typing, multilocus enzyme electrophoresis (MLEE); Molecular typing: RAPD, rep (REP, ERIC, BOX)-PCR, IS based typing PFGE, AFLP, MLST, VNTR and whole genome sequence, use of geographical information system (GIS) for microbial epidemiology.

UNIT – III (4 hours)

Environmental change and infectious diseases: Global warming-led increase in vector-borne and water-borne infectious diseases; Impact of increasing urbanization, international travel and trade on infectious diseases.

UNIT – IV (8 hours)

Rapid diagnostic principles

Nucleic acid probes in diagnostic microbiology, nucleic acid amplification methods, real-time PCR, lateral flow assays, diagnostic sequencing, mutation detection, automated instruments for detection/ diagnosis of infectious agents (BACTAC and Vitek-2, GeneXpert).

Practical component (30 hours):

1. To study resident microflora of skin.
2. To study resident microflora of the oral cavity.
3. To study cultural characteristics of pathogenic bacteria on the following selective/differential media: TCBS agar; Hektoen Enteric agar; XLD agar; Endo agar; Salmonella-Shigella agar; Deoxycholate citrate agar.
4. To study the pathogenicity of *Staphylococcus aureus* by coagulase test.
5. To perform the rapid (P/A format) coliform test.
6. To study antimicrobial susceptibility testing using an octa disc.
7. To determine minimal inhibitory concentration (MIC) of an antibiotic using an E-test.
8. To determine the minimal inhibitory concentration (MIC) of an antimicrobial compound by micro-broth dilution method.
9. To perform minimal bactericidal concentration (MBC) of an antimicrobial compound.
10. To perform sterility testing of a sample.

Essential/recommended readings

1. Jawetz, Melnick, &Adelberg's Medical Microbiology by Carroll KC, Hobdon JA, Miller S, Morse SA, Mietzner TA. 27th edition. Lange Publication, 2016.
2. Beginner’s guide to comparative genome analysis using next generation sequence

data by Edward DJ and Holt KE in Microbial Informatics and Experimentation, 3:2, https://doi.org/10.1186/2042-5783-3-2, 2013.

3. Bacterial Pathogenesis: A molecular approach by Wilson BA, Salyers AA, Whitt DD, Winkler ME. 3rd edition. American Society for Microbiology Press. 2011.
4. Bacterial Pathogenesis: Molecular and Cellular Mechanisms by Locht C, Simonet M. Caister Academic Press. 2012.
5. Molecular Microbiology: Diagnostic Principles and Practice by Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. 3rd edition. American Society for Microbiology Press. 2016.
6. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM. 4th edition. Jones and Bartlett. 2019.

Practicals:

1. Microbiology: A laboratory manual by JG Cappucino, C.T. Welsh. 11th edition. Pearson. 2017.

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DISCIPLINE SPECIFIC ELECTIVE COURSE: DSE-01 IMMUNOLOGY

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		
DSE-01: IMMUNOLOGY	4	3	0	1	B.Sc. in any branch of Life Science	NONE

Learning Objectives:

- The objective of this course is to understand the various components of the host immune system, their structure and organization, and their functions to serve as the defence system of the body.
- It would also help the students understand the operational mechanisms which underlie the host defense system, allergy and organ transplantation.

Learning Outcomes:

Upon successful completion of the course:

- The student will be able to understand the fundamental bases of the immune system and immune response
- The student will be able to gather information about the structure and organization of various components of the immune system
- The student will be able to comprehend the genetic organization of the genes meant for the expression of immune cell receptors and the basis of the generation of their diversity
- The student will be able to understand the operation and the mechanisms which underlie the immune response
- The student will be able to apply the knowledge gained to understand phenomena like host defense, hypersensitivity (allergy), organ transplantation and certain immunological diseases

SYLLABUS OF DSE-01

UNIT-I (12 hours)

Overview of Immune system: History of immunology. An immune system of our microbial universe. Three fundamental concepts in immunology: Specificity, discrimination of self from non-self and memory. Innate immunity and inflammation: Innate vs. adaptive immunity. . Resident sentinel cells and their role in innate immunity. Contrast antiviral and antibacterial immune response. Role of Type-I IFN. Cells of innate immunity. Pus formation. Microbial recognition and responses in the innate immune system: PAMPs and PRRs (function of different TLRs and other receptors). Signals for Innate Immunity. Introducing complement.

Agglutinins and complement proteins. Complement pathways. Diseases Linkage (Hepatitis as an example).

UNIT-II (16 hours)
Immune cell receptors and Genetic Organization: Detailed structure and development of B cell (Ig) and T cell (TcR) receptors; Structure of CD4, CD8, MHC-I, MHC-II molecules, cellular adhesion molecules (ICAM, VCAM, selectins, integrins); Pattern Recognition Receptors (PRRs) including Toll-like receptors (TLR), RIG like Receptors (RLR) and Nucleotide-binding Oligomerization Domain Like Receptors (NLRs) ; Markers of suppressor / regulatory cells - CD4+ CD25+ Foxp3+Treg , iNKT. Lymphocyte development and diversity: Organization of the genes for B and T cell receptors. Genetic organization of MHC-I and MHC-II complex (both HLA and H-2). Molecular mechanisms responsible for generating diversity of antibodies and T cell receptors. Peptide loading and expression of MHC-I and MHC-II molecules (Lysosomal and Proteasomal pathways); Hybridoma technology and monoclonal antibodies, antibody-engineering including bispecific antibodies.

UNIT- III (12 hours)
Immune response and signaling: Humoral and cell-mediated immune response; Innate immune response and pattern recognition; Recent advances in innate immune response especially NK-DC interactions; Important cytokines and their role in immune mechanisms: TNF, IFN-γ, IL-1, IL-2, IL-4, 1L-6, 1L-12, IL-17, TGFb; Cell signaling through MAP kinases and NF-kB. T cell activation by antigens (Role of dendritic cells and antigen presentation. Activation of DCs. Co-stimulation and Two-Signal requirement). T-cell dependent B-cell responses (Clonal selection and expansion, formation of germinal centers, affinity maturation and isotype switching). Helper T cells (TH-1, TH2 and TH17 cells) and functions. Effector functions of Cytotoxic T cells and therapeutic checkpoints.

UNIT- IV (5 hours)
Immunological disorders and hypersensitivity: Deficiencies/defects of T-cells, B-cells, and phagocytic cells; Comparative study of Type I-V hypersensitivities with examples.

Practical component (30 hours):

1. To study morphological and staining characteristics of lymphocytes, neutrophils, monocytes, eosinophils, and basophils.
2. To perform immune-electrophoresis.
3. To perform radial immune-diffusion assay.
4. To perform rocket immune-electrophoresis.
5. To study quantitative precipitation assay.
6. To perform latex agglutination test.
7. To perform dot-ELISA.
8. To perform sandwich ELISA (antigen capture or antibody capture).

Essential/recommended readings

1. Kuby Immunology by J.A. Owen, J. Punt, S.A. Stranford. 7th edition. WH Freeman. 2013.
2. Cellular and Molecular Immunology by A.K. Abbas, A.H. Lichtman, S. Pillai. 9th edition. Saunders Elsevier. 2018.

3. Janeway's Immunobiology by K. Murphy, W. Casey. 9th edition. Garland Science Publishing. 2017.
4. Review of Medical Microbiology and Immunology by W.Levinson. 15thedition.Lange Publication. 2018.
5. Fundamental Immunology by W.E. Paul. 7th edition. Lippincott Williams and Wilkins. 2013.
6. Roitt's Essential Immunology by P.J. Delves, S.J. Martin, D.R. Burton, I.M. Roitt. 13th edition. Blackwell Publishing. 2017.

Practicals:

1. Microbiology: A laboratory manual by JG Cappucino, C.T. Welsh. 11th edition. Pearson. 2017.

DISCIPLINE SPECIFIC ELECTIVE COURSE: DSE-02
CELL 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		
DSE-02: CELL BIOLOGY	4	3	0	1	B.Sc. in any branch of Life Science	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to introduce the students to fundamental and advanced concepts in cellular organization, signaling, and function
- The students will gain knowledge and in-depth understanding of cellular structures, functions, and interactions at the molecular level
- The course will familiarize the students with stem cells and cancer cell biology

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the cellular compartments and organelles present in eukaryotic cells in detail; and will be able to differentiate between prokaryotic and eukaryotic cells
- Student will be able to evaluate different types of cell signaling and signal transduction pathways
- Student will be able to describe the different phases of the cell cycle, and understand cell cycle checkpoints and regulatory molecules.
- Student will be able to understand more about stem cells and differentiation including cancer cells.

SYLLABUS OF DSE-02

UNIT – I (12 hours)

Cell Structure & Organization: Subcellular compartments: Nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus. Prokaryotic vs. Eukaryotic cells. Plasma membrane: Structure and function, Membrane dynamics and lipid rafts. Cytoskeleton structure and functions (actin, microtubules,microfilaments, intermediate filaments). Organelle biogenesis and trafficking (ER, Golgi, lysosomes, peroxisomes). Endocytosis, exocytosis, and vesicular transport

UNIT – II (9 hours)
Cell Signaling & Communication: Types of signaling: Paracrine, autocrine, endocrine, synaptic. Signal transduction pathways: GPCRs, RTKs, JAK-STAT, MAPK. Second messengers: cAMP, Ca^{2+}. Regulation of cellular responses to external signals

UNIT – III (12 hours)
Cell Cycle and Regulations and Cancer: Phases of the cell cycle (G1, S, G2, M). Checkpoints and regulatory molecules (Cyclins, CDKs, tumor suppressors). Mechanisms of apoptosis and necrosis. Oncogenes and tumor suppressors in cancer. Hallmarks of cancer and tumor microenvironment. Oncogenes and tumor suppressor genes. Metastasis and angiogenesis. Targeted therapies and drug resistance mechanisms

UNIT – IV (12 hours)
Stem Cells ,Differentiation and Development of Multicellular organisms: Pluripotency and stem cell niches. Cellular reprogramming and induced pluripotent stem cells (iPSCs). Types of stem cells: Embryonic, adult, induced pluripotent (iPSCs). Mechanisms of differentiation and dedifferentiation. Stem cell applications in regenerative medicine. Overview of development. Mechanism of pattern formation: Hox protein, Trithorax and Polycomb Group protein. Morphogenesis and growth. Neural development.

Practical component (30 hours)

1. Culturing human cancer cell lines, seeding and splitting of cell lines
2. Cryopreservation of human cell lines in Liquid Nitrogen.
3. Performance of nuclear staining of Hela cell lines by DAPI and Hoechst stain.
4. Cytoskeleton staining of F-actin, Lysosome staining and Mitochondria staining

Essential/recommended readings

Theory:

1. Essential Cell Biology by Alberts, B., Hopkin, K., Johnson, A.D., Morgan, D. and Raff, M. 5th edition. WWNorton & Co, USA. 2019.
2. Molecular Cell Biology by H. Lodish, A. Berk, C. Kaiser, M. Krieger, A. Bretscher, H.Ploegh, A. Amon and K.C. Martin. 9th edition. W.H. Freeman, UK. 2021.
3. Cell and Molecular Biology by G. Karp, J. Iwasa, W. Marshall. 9th edition. Wiley, USA. 2019.

Practicals:

1. Cell Biology: A laboratory handbook by Julio E. Celis. 3rd Edition. Academic Press. 2006.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE: DSE-03 MOLECULAR 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		
DSE-03: MOLECULAR BIOLOGY	4	3	0	1	B.Sc. in any branch of Life Science	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The purpose of this course is to introduce the student to the advanced concepts in molecular biology.
- Students will gain an understanding of molecular mechanisms of DNA replication, DNA repair, transcription, translation, and gene regulation in prokaryotic and eukaryotic organisms.
- The student will study the techniques and experiments used to understand these mechanisms.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe the structure of DNA and RNA, and the organization of the eukaryotic genome.
- Students will be able to compare and contrast the mechanisms of bacterial and eukaryotic DNA replication, DNA repair, and transcription.
- Students will be able to explain concepts in DNA mutation mechanism, DNA repair mechanisms, and recombination as a molecular biology tool.
- Students will be able to explain various levels of gene regulation in both prokaryotic and eukaryotic organisms.
- Students will be able to describe post-transcriptional processes, RNA editing and RNA transport.
- Students will be able to understand the translation mechanism in prokaryotes and eukaryotes, regulation, and post-translational processing.
- Students will be able to describe post-translational processes.

SYLLABUS OF DSE-03

UNIT – I (8 hours)

The nature of genetic material: Background about DNA discovery, the structure of DNA and RNA; selection of DNA over RNA, melting of DNA, complexity of the DNA and Cot curve analysis, superhelicity. Organization of genomes: organization of microbial genomes, organization of eukaryotic genomes, chromatin arrangement, nucleosome formation, nucleosome sliding.

UNIT – II (10 hours)

DNA replication: Arrangement of replicons in a genome, various modes of replication, continuous, discontinuous synthesis, various replication enzymes, replication fork, priming, leading and lagging strand, initiation, elongation, termination. Specific features of prokaryotes and eukaryotes replication, action of topoisomerases, Telomerase: telomere maintenance. Fidelity, Processivity and Catalytic Efficiency of DNA Polymerases. Relationship between DNA replication and cell cycle, DNA copy number maintenance. **Repair of DNA:** Mutation and DNA repair, mechanisms of mutation, DNA mismatch repair, Base excision repair/Nucleotide excision repair, double Strand Break repair and recombination.

Unit – III (15 hours)

Transcription mechanism and regulations: Transcription machinery of prokaryotes: various transcription enzymes, cofactors, sigma factors. Mechanism of transcription: initiation, elongation, and termination. Transcription machinery of eukaryotes: various forms of RNA polymerase and cofactors, promoters. Mechanism of transcription: initiation, elongation and termination. Regulation of transcription: enhancers, silencers, activators, the effect of chromatin structure. **Post-transcriptional processes:** RNA processing: capping and polyadenylation, splicing mechanism: group-I, group-II, and pre-mRNA splicing. Alternate splicing, rRNA and tRNA processing, RNA transport, and RNA Editing. Post-transcriptional gene regulation.

UNIT – IV (12 hours)

Translation: The genetic code and degeneracy of genetic code. Essential components of translation in prokaryotes: ribosome structure, tRNA structure, Aminoscyl tRNA synthetase. Process of translation: initiation, elongation and termination. Essential component of translation in eukaryotes, Process of translation: initiation complex, elongation and termination. In vitro translation systems, polysomes, polycistronic/ monocistronic synthesis. Regulation of translation, RNA instability, inhibitors of translation. **Post-translational processes**: Protein modification, folding, chaperones, transportation. The Signal Hypothesis. Protein degradation.

Practical component (30 hours):

1. Transcriptional analysis of mRNA using Northern Blotting.
2. Analysis of mRNA using reverse transcription-polymerase chain reaction (RT-PCR).
3. Analysis of expression of heterologous proteins in *E. coli* host cell using SDS-PAGE followed by coomassie staining.
4. Impact of temperature, concentration of inducing agent, and induction time on the protein expression.
5. Analysis of expression of proteins using western blotting.

Essential/recommended readings

Theory:

1. Molecular Cell Biology by H. Lodish, A. Berk, C. Kaiser, M. Krieger, A. Bretscher, H.Ploegh, A. Amon and K.C. Martin. 9th edition. W.H. Freeman, UK. 2021.
2. Essential Cell Biology by Alberts, B., Hopkin, K., Johnson, A.D., Morgan, D. and Raff, M. 5th edition. W.W. Norton & Co, USA. 2019.
3. Karp's Cell and Molecular Biology by G. Karp, J. Iwasa and W. Marshall. 9th edition. Wiley, USA. 2019.
4. The Cell: A Molecular Approach by G.M. Cooper. 8th edition. Oxford University Press, UK. 2018.
5. Cell and Molecular Biology by E.D.P. De Robertis and E.M.F. De Robertis, Jr. 8th edition. Lippincott, Williams and Wilkins, USA. 2006.
6. Biochemistry by Berg, J.M., Tymoczko, J.L., Gatto, G.J., and Stryer, L. 9th edition. W.H. Freeman and Company, UK. 2019.
7. Lewin's Genes XII by Krebs, J., Goldstein, E. and Kilpatrick, S. 12th edition. Jones and Bartlett Learning, USA. 2017.
8. Molecular Biology of the Gene by Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. 7th edition. Cold Spring Harbour Laboratory Press, USA. 2014.
9. Molecular Biology by Weaver, R.F. 4th edition. McGraw Hill, USA. 2007.

Practicals:

1. Molecular Cloning: A laboratory manual by Joseph Sambrook, David Russell, 4th edition. Cold Spring Harbor Laboratory Press. 2012.
2. Current Protocols in Molecular Biology by F. M. Ausubel, R. Brent, R.E. Kingston, D. D. Moore, J. A. Smith, K. Struhl (editors). John Wiley and Sons, USA. 2007.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE : DSE-04
PLANT PATHOGEN INTERACTIONS

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-04: PLANT PATHOGEN INTERACTION	**4**	**3**	**0**	**1**	**B.Sc. in any branch of Life Sciences**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course aims to give students an overview of how pathogens interact with various plants and affect plant physiology, including photosynthesis, respiration, transpiration, and translocation.
- They will learn about strategies for studying physiology, photosynthesis, respiration, transpiration, and translocation in plants
- Students will gain insight into molecular interactions and the roles of various enzymes and toxins will assist in developing biocontrol strategies and creating transgenic plants.
- Students will learn about viral diseases, their management and the diseases impacting key cereals, vegetables, and crops.
- They will be introduced to the genetics of host-pathogen interactions, including plant resistance genes and mechanisms.
- They will learn about innovative strategies in molecular diagnostic methods and accurate forecasting of plant diseases.

Learning Outcomes:

The Learning Outcomes of this course are as follows:

- The student will be able to describe various causes of plant diseases and the effects of microbial infections on plant physiology, photosynthesis, respiration, transpiration, and translocation.
- The student will learn about various enzymes and toxins involved in plant diseases and the role of phytoalexins.
- The student will comprehend the information regarding crown gall, the symptoms of viral diseases and their control, and the diseases affecting some important cereals, vegetables, and crops.

- The student will gain knowledge of various traditional and plant disease control methods, including physical, chemical, and biological approaches.
- The student gains insight into the genetics of host-pathogen interactions, including resistance genes and mechanisms in plants.
- The student will differentiate between several modern molecular diagnostics for plant disease and the development of transgenic plants, along with their applications and constraint
- The student will acquire insight into various important disease control and forecasting milestones relevant to Indian farming.

SYLLABUS OF DSE-04

UNIT-I (7 hours)
Concepts and physiology of plant diseases: Causes of disease, pathogenesis, pathogenesis in relation to environment, effect of microbial infections on plant physiology, photosynthesis, respiration, transpiration, translocation

UNIT-II (18 hours)
Biochemical and Genetic basis of plant diseases and their control strategies: Enzymes and toxins in plant diseases, phytoalexins. Genetics of host-pathogen interactions, resistance genes, resistance mechanisms in plants, Principles of plant disease control, physical and chemical methods of disease control, biocontrol, biocontrol agents - concepts and practices, fungal agents, *Trichoderma* as biocontrol agent, biocontrol agents – uses and practical constraints.

UNIT -III (10 hours)
Some important plant diseases and their etiological studies: Crown gall, symptoms of viral diseases and their control, diseases of some important cereals, vegetables and crops.

UNIT- IV (10 hours)
Molecular diagnostic and Disease forecasting approach: Molecular diagnosis, transgenic approach for plant protection, futuristic vision of molecular diagnosis, applications and constraints. History and important milestones in disease control, disease forecasting and its relevance in Indian farming.

Practical component (30 hours)

1. Isolation of pathogens from soil.
2. Isolation of pathogens from plant tissue,
3. Biochemical and physical identification of plant pathogens
4. Chemical control of soil-borne pathogens using Acylanilide and Alkyl phosphonates.
5. Preparation of plant pathogen genomic DNA
6. Antibody-based testing of plant pathogens (ELISA and Western blot) and PCR amplification and 16S sequencing.
7. Quantification of pathogens population in infected plant samples using qPCR

Suggested Readings:

1. Plant Pathology by G. N. Agrios. 5th edition. Academic Press. 2005
2. Plant Pathology by R.S. Mehrotra, and A. Aggarwal, 3rd edition. Tata McGraw Hill. 2017
3. Bacterial plant pathology: cell and molecular aspects by D. C. Sigee. Cambridge University Press.1993.
4. Molecular plant pathology by M. Dickinson. BIOS Scientific Publishers, London. 2003.
5. The essentials of Viruses, Vectors, and Plant diseases by A.N. Basu & B.K. Giri. Wiley Eastern Limited.1993.
6. Biocontrol of Plant Diseases (Vol. I) by K.G. Mukerji and K. L. Garg. CRC Press Inc.,USA.1988.
7. Molecular Biology of Filamentous Fungi by U. Stahl and P. Tudzyski. VCH VerlagsgesellschaftmbH. 1992.
8. Molecular Cloning: A laboratory manual by Joseph Sambrook, David Russell, 4th edition. Cold Spring Harbor Laboratory Press. 2012.

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

GENERIC ELECTIVE COURSE: GE-01
ESSENTIALS OF MICROBIOLOGY

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		
GE-01: ESSENTIALS OF MICROBIOLOGY	4	3	1	0	-	None

Learning Objectives:
- The objective of this course is to make the students understand various basic aspects of microbiology.
- The students will learn about different microbial diseases and will be exposed to role of microbes in the food industry.
- The course would enable students to understand the applied aspects of microbiology.

Learning Outcomes:
Upon successful completion of the course:
- The student will be able to understand different types of microbes and contrast it with eukaryotic cell
- The student will be able to describe the epidemiology, methods of diagnosis and treatment of bacterial and viral infections
- The student will be able to study and critique the various sources of fungal infections and protozoan diseases
- The student will be able to get glimpses of microbial spoilage, food safety concerns, and regulations
- The student will be able to gather information about the microbial growth and control of bacterial growth for bioprocesses
- The student will be able to understand the importance of microbes in the environment and how the microbes adapt to extreme conditions.
- The student will be practice and relate the theory portions in the tutorial sessions.
- The student will be exposed to real world problems in the tutorial sessions

SYLLABUS OF GE-01

UNIT – I (6 hours)
Introduction to Microbial Life: Origins of Microbiology, Use of microscopy in Microbiology, Contributions of Louis Pasteur and Robert to early microbiology, discovery of microbial diversity and introduction to groups of microbes. Microbial cell structure using bacterial as a model system. Role of microbes in gut.

UNIT – II (18 hours)

Microbes and human diseases: Introduction to virology, common strategy of viruses, virus infection cycle, virus infection basics, viral spread, pathogenesis of viral-diseases- influenza, Polio. Emerging viruses. Epidemiology and disease microbiology, diagnostics, treatment of important bacterial diseases: tuberculosis, colitis, urinary tract infections, meningitis, pneumonia and dental caries and medical device associated bacterial infections. Fungi and Protozoans human diseases: Deadly mushrooms, Mode of transmission of fungal pathogens (airborne, arthropod and direct contact). Food and water as a source of fungal infections. Opportunistic fungal pathogens. Understanding the etiology, epidemiology, diagnostics and treatments of important protozoan diseases such as Malaria, Leishmaniasis, Trypanosomiasis and amoebiasis.

Unit – III (14 hours)

Food Microbiology, Microbial Growth kinetics and bioprocess development: Microbial spoilage of food. Environmental factors. Food-borne disease out breaks. Diagnostics of food-borne pathogens. Regulations in food safety. Microbiology of beer, cheese etc. Microbial growth kinetics, Stoichiometric calculations of growth parameters, Measurement of biomass and product yields coefficients, Cellular maintenance requirements, Monod batch kinetics, Fed-batch fermentation, Continuous Stirred Tank Reactors (CSTRs), Operational strategies for high cell density fermentation

Unit – IV (7 hours)

Environmental Microbiology: Overview of environmental microbiology. Study of microbial diversity in the environment by culture-dependent and independent approaches. Diversity, adaptations, and biotechnological applications of extremophiles. Exploration of extremophiles in space research and astrobiology. Soil and water microbiology, plant-microbe interactions, drinking water microbiology. Microbial applications in bioremediation and waste treatment.

Tutorial Component (15 hours)

The tutorial will include:

1. Group discussions: Clinical case studies and research articles covering beneficial as well as harmful pathogens of relevance.
2. Group and Individual assignments: Relevant to harmful and beneficial microbes.
3. Flip classroom training and assessment: Presentation preparation, Q & A covering the theory taught in the main lectures.

Essential/recommended readings

1. Brock Biology of Microorganisms by Madigan, Bender, Buckley, Sattley and Stahl. 15th Edition. Pearson Global Edition. 2018.
2. Microbiology by Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. 5th edition. McGraw Hill, USA. 1993.
3. General Microbiology by Stanier, R.Y., Ingrahm, J.I., Wheelis, M.L. and Painter, P.R. 5th edition. McMillan Press, UK. 1987.
4. Microbiology: An Introduction by Tortora, G.J., Funke, B.R., Case, D., Weber, D. and Bair, W. 13th edition. Pearson Education, USA. 2019.

5. Introduction to fungi by Webster, J. and Weber, R. 3rd edition. Cambridge University Press, UK. 2007.
6. Prescott's Microbiology by Willey, J. M., Sandman, K. and Wood, D. 11th edition. McGraw Hill Higher Education, USA. 2019.
7. Microbiology: A Laboratory Manual by Cappuccino, J. and Welsh, C.T. 11th edition. Pearson Education, USA. 2016.
8. Principles of Fermentation Technology by Peter Stanbury, Allan Whitaker, Stephen Hall Butterworth-Heinemann. 3rd edition. 2016.
9. Bioprocess Engineering: Basic Concepts by Michael L. Shuler and Fikret Kargi. 2nd Edition. Pearson Education India. 2015.
10. Modern Industrial Microbiology & Biotechnology by N. Okafer. CRC Press, USA. 2007.

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

GENERIC ELECTIVE COURSE: GE-02
MICROBIAL BIOTECHNOLOGY

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		
GE-02: MICROBIAL BIOTECHNOLOGY	4	3	1	0	-	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- This course aims to give students an overview of the various applications of microbes in developing products for agriculture, industry, and clinical use.
- Students will become familiar with cellular growth and the kinetics of product formation.
- Students will gain knowledge of recombinant expression platforms for product development.
- Students will develop an understanding of the construction and types of laboratory and industrial-scale bioreactors.
- They will explore different fermented foods and beverages and their health benefits.
- They will learn about various strategies for optimizing bioprocesses to establish multiple industrial production methods.
- Students will learn about the various regulatory approval requirements for drug development.

Learning Outcomes:

Upon successful completion of the course, the student:

- The student will understand various microbial products relevant to industry and their production processes, as well as the role of biotechnology in environmental management.
- The student will grasp the strain development process and the selection of high-yield producers.
- The student will become skilled in designing recombinant heterologous expression systems, including *E. coli,* yeast, and mammalian cells.
- The students will understand the reactor scale sterilization process and the available strategies.
- The student will be well-informed about designing large-scale industrial processes and different cultivation strategies.

- The student will understand recombinant biomolecules, therapeutic proteins, biopesticides, biofertilizers, and probiotics.
- The student will scrutinize the different types of regulatory approvals required for drug development, as well as the differences between biologics, biosimilars, and biobetters.

SYLLABUS OF GE-02

UNIT-I (5 hours)
Introduction to microbial biotechnology: Historical developments of microbial biotechnology, Biotechnology, and its applications in microbial processes. BioE3 (Biotechnology for Economy, Environment, and Employment) Policy Role of microbial biotechnology in environment management. What is bio-manufacturing and bio-foundry

UNIT-II (14 hours)
Microbial growth Kinetics and Designing large-scale industrial processes: kinetics microbial growth and product formation, measurement of growth and product formation kinetics, diauxic growth, Aerobic and anaerobic fermentation, Application of bioprocess engineering in microbial product development, batch fermentation, fed-batch fermentation, type of bioreactors, designs and control parameters in a fermenter, high cell density cultivation strategies, continuous cultivation processes, limiting parameters in large-scale process development, oxygen mass transfer coefficient.

UNIT-III (16 hours)
Improvement of Microbial strains, Sterilization operations and Recombinant gene expression platforms: Strains development, selection of hyper producers, microbial products, Mutagenesis approaches for the selection of induced mutants, Strategies for metabolic and flux engineering in the development of industrial products; Different types of sterilization strategies, sterilization of large-scale bioreactors, calculation of heating, holding, and cooling time. Continuous and batch sterilization operations. Microbial death kinetics. Effects of sterilization on media quality, Development of recombinant heterologous expression systems e.g. *E. coli*, yeast, and mammalian. Plant cells as bio-factories. Control parameters in the stability of these expression platforms at the industrial scale. Soluble and insoluble expression of recombinant products. Advantages and disadvantages of inclusion bodies. Refolding strategies for inclusion bodies. Role of signal sequences in extracellular product secretions.

UNIT-IV (10 hours)
Development of microbial products, Regulatory approvals and clinical trials:: Fermented milk products, fermented vegetables, probiotics, malt beverages, wines, distilled liquors, recombinant biomolecules, therapeutic proteins, therapeutic enzymes, industrially important enzymes, and green fuel production, bioethanol and biodiesel, Development of bio-pesticides and bio-fertilizers. Good laboratory practice (GLP), Current Good Manufacturing Practice (CGMP), different phases of clinical trials, intellectual property rights, difference between biologics, biosimilar, and bio-better, development of biosimilars and generic biomolecules, analysis of process economics

Tutorial Component (15 hours)

1. Discussion about development of Biosimilar and generic drugs
2. Students will study 10 latest approved biological by FDI
3. Designing of upstream and downstream equipment's using cost effective strategies.
4. Study about process control and role of AI shall be discussed through student's presentation.
5. Designing artificial metabolic flux network for strain improvements.
6. Problem solving using different feed-back control mechanism for optimal process parameters

Suggested Readings:

1. Principles of Fermentation Technology by P. Stanbury, A. Whitaker, S. Hall. 3rd edition. Butterworth-Heinemann. 2016.
2. Modern Industrial Microbiology & Biotechnology by N. Okafor. 1st edition. CRC Press, USA. 2007.
3. Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer and H. Nikaido. 2nd edition. Cambridge University Press. 2007.
4. Pharmaceutical Biotechnology: Concepts and Applications by G. Walsh. John Wiley & Sons Ltd. 2007.
5. Pharmaceutical Biotechnology: Fundamentals and Applications by J.A.D. Crommelin, R. D. Sindelar, and B. Meibohm. 4thEdition. Springer. 2013.

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

SKILL ENHANCEMENT COURSE: SEC-01
BASIC MICROBIOLOGICAL TECHNIQUES

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		
SEC-01: BASIC MICROBIOLOGICAL TECHNIQUES	2	0	0	2	B.Sc. in any branch of Life Science	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this paper is to develop a clear understanding of various microbiological techniques and their application.
- This course will train the students to analyze bacterial motility and pigment production.
- Students will be able to gain knowledge of fluorescence microscopy techniques for live cell imaging.
- The course will develop the skill to use a spectrophotometer and estimate the concentration of protein and DNA.
- The students will be trained to analyze the bacterial biofilm growth on different substrates.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to illustrate whether a given bacteria is motile and producing the pigments.
- Student will be able to demonstrate the use of florescence microscopy for studying sub-cellular localization of proteins and/or viruses.
- Students will be able to estimate the concentration of protein(s) and DNA.
- Students will be able produce bacterial biofilm on different substrates.

SYLLABUS OF SEC- 01

UNIT – I (30 hours)

Bacterial Motility assay and pigment production assays: Plate based assays to assess different types of motilities in bacteria. Quantifying pigment production in bacteria (pyocyanin and pyoverdine production in *Pseudomonas aeruginosa*). **Viral pathogenesis:** Studying virus infection progression in virus-infected cells using GFP labeled virus and fluorescent microscopy. Live/ fixed cell imaging using GFP labeled protein for sub-cellular localization.

UNIT – II (30 hours)
Estimation of protein and DNA: To prepare a standard curve of BSA and determine the concentration of unknown protein samples using the Bradford method. Determination of DNA concentration using a spectrophotometer. **Planktonic vs. Sessile mode of growth in bacteria:** Growing biofilms of bacteria on different substrates and effect of different growth conditions on biofilms.

Essential/recommended readings

1. Microbiology, A laboratory manual by James G. Cappuccino and Chad T. Welsh, Pearson Education, 2021
2. A Cell Biology Manual BY J. Francis. Kendall. Hunt Publishing Co, USA. 2022.
3. Practical Laboratory Manual- Cell Biology by A. Gupta, B.K. Sati. Lambert Academic Publishing, USA. 2019.
4. Cell Biology Practical Manual by R. Gupta, S. Makhija and R. Toteja. Prestige Publishers, India. 2018.
5. Laboratory Manual of Cell Biology by R. Majumdar, R. Sisodia. Prestige Publishers, India. 2018.
6. Essential Cell Biology Vol **1**: Cell Structure- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.
7. Essential Cell Biology Vol **2**: Cell Function- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.
8. Microbiology: A laboratory manual by JG Cappucino, CT Welsh. 11th Edition. Pearson. 2017.

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

SKILL ENHANCEMENT COURSE: SEC-02
ENVIRONMENTAL, INDUSTRIAL & MOLECULAR MICROBIOLOGY TECHNIQUES

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		
SEC-02: ENVIRONMENTAL, INDUSTRIAL & MOLECULAR MICROBIOLOGY TECHNIQUES	2	0	0	2	B.Sc. in any branch of Life Science	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to introduce students to essential microbiological techniques related to water, soil, dairy microbiology, enzyme activity, and molecular biology.
- The students will gain hands-on experience assessing microbial water quality and soil health using standard microbiological methods.
- They will develop proficiency in enzyme screening and activity assays for industrially relevant microbial enzymes.
- Students will study the growth behavior of microorganisms, calculating specific growth rates, biomass yields, and product yields.
- The student will be introduced to the application of molecular techniques in Microbiology.

Learning Outcomes

The Learning outcomes of this course are as follows:

- Students will be able to assess the microbiological quality of water using MPN and selective media for pathogen detection.
- Students will be able to analyze soil's physical and microbial properties and evaluate microbial activity using biochemical assays.
- Students will be able to perform and interpret enzyme screening and activity assays for amylase, lipase, xylanase, and cellulase.
- Students will be able to determine the efficiency of milk pasteurization through MBRT and alkaline phosphatase tests.
- Students will be able to evaluate microbial metabolic activity in environmental samples using FDA hydrolysis and nitrate reduction assays.
- Students will be able to describe the methods used for growth measurement.

- Students will be able to execute the Polymerase Chain Reaction to optimize the PCR yield.

SYLLABUS OF SEC-02

UNIT-I (30 hours)

Dairy Microbiology and Quality Control: To perform MBRT with a given milk sample. To perform an alkaline phosphatase test to check the milk sample pasteurization efficiency. To determine microbial activity in soil by estimating FDA hydrolysis. **Isolation and Screening of Enzymes:** To isolate and screen amylase, lipase, xylanase, and cellulase-producing microorganisms using the enrichment culture technique. To determine amylase and xylanase activity using the DNSA assay.

Unit- II (30 hours)

Microbial Cultivation and Optimization for Bioprocessing: Preparation of growth media; microbial inoculation for primary and secondary cultures; optimization of growth conditions (physical and chemical parameters); production of microbial enzymes; measurement of enzymatic activity. **Molecular Techniques in Microbiology: Polymerase Chain Reaction (PCR):** Amplification of gene(s) using Polymerase Chain Reaction (PCR). PCR components, PCR steps, and optimization of annealing temperature. Visualization of amplified DNA using agarose gel electrophoresis. Working of agarose gel electrophoresis: preparation of agarose gel, DNA sample preparation and loading, observation, and interpretation. Gradient Polymerase Chain Reaction amplification of gene(s).

Suggested Readings:

1. Environmental Microbiology of Aquatic & Waste Systems by N. Okafor. 1stedition, Springer, New York. 2011.
2. Environmental Microbiology: A Laboratory Manual by C.J. Hurst. 2nd Edition. American Society for Microbiology, 2016.
3. Molecular Cloning: A laboratory manual by Joseph Sambrook, David Russell, 4th Edition. Cold Spring Harbor Laboratory Press. 2012.
4. Current Protocols in Molecular Biology by F. M. Ausubel, R. Brent, R.E. Kingston, D. D. Moore, J. A. Smith, K. Struhl (editors). John Wiley and Sons, USA. 2007
5. Molecular Microbiology: Diagnostic Principles and Practice by Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. 3rd Edition. American Society for Microbiology Press. 2016.
6. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM. 4th Edition. Jones and Bartlett. 2019.
7. Microbiology: A laboratory manual by JG Cappucino, CT Welsh. 11th Edition. Pearson. 2017.
8. Bioprocess Engineering: Basic Concepts by Michael L. Shuler and Fikret Kargi. 2nd Edition. Pearson Education India. 2002.
9. Modern Industrial Microbiology & Biotechnology by Nduka Okafor and Benedict C. Okeke. 2nd Edition. CRC Press, USA. 2017.
10. Microbial Biotechnology: Fundamentals of Applied Microbiology by Alexander N. Glazer and Hiroshi Nikaido. 2nd Edition. Cambridge University Press. 2007.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch,

University of Delhi, from time to time.

Annexure-4

UNIVERSITY OF DELHI

MASTER OF SCIENCE
(TWO-YEAR PROGRAMME)
IN
PLANT MOLECULAR BIOLOGY AND BIOTECHNOLOGY
(Effective from the Academic Year 2025-2026)

BROCHURE

Revised on 18.07.2025 in response to the comments received
(Ref. E.C. 23.05.2025 Annexure -4.09.04)

Department of Plant Molecular Biology
Faculty of Interdisciplinary and Applied Sciences
University of Delhi, South Campus
New Delhi – 110 021, India

NEP 2020 based syllabus as approved in the meeting of 'Committee of Courses' held on ________in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on ___________, and meeting of 'Standing Committee' held on_____________

Revised Syllabus as approved by Academic Council on _____, 2025
and
Executive Council on _____, 2025

Contents

I. About the Department

The **Department of Plant Molecular Biology,** established in 1988 under the Faculty of Interdisciplinary and Applied Sciences, advances research and education in frontier areas of plant molecular biology and biotechnology. It was enriched by the merger of the **Unit for Plant Cell and Molecular Biology** in 1988 (originally established by the DST) and the award of 'Committee on Strengthening of Infrastructure for Science and Technology (COSIST)' grant by the UGC (1990–1995). The Department was recognized under UGC's Special Assistance Programme (DRS Phase I-III, 2002-2018) to strengthen research and teaching in Functional Genomics. Since its inception, the Department has been led by eminent scientists, including Prof. S.C. Maheshwari (1988–1992), Prof. Akhilesh K. Tyagi (1988, 1992–95, 1998–2001), Prof. Jitendra P. Khurana (1995–1998, 2001–2004, 2014–2016), Prof. Paramjit Khurana (2004–2007, 2016–19), Prof. Anil Grover (2007–2010, 2019–22), Prof. Indranil Dasgupta (2010–2013), Prof. Madan Mohan (2013–2014), and Prof. Sanjay Kapoor (current Head, since 2022).

We are one of India's top-ranking institutions for Plant Science Education and Research, nestled within the secure and picturesque South Campus of the University of Delhi. With Delhi University's rich legacy of academic and research excellence, the Department of Plant Molecular Biology is committed to upholding and advancing this tradition through its innovative teaching and cutting-edge research programmes. Since its establishment, DPMB has been at the forefront of numerous multinational research initiatives, fostering a dynamic and globally connected research community, notably those funded by the Rockefeller Rice Biotechnology Program (1990-2000), which bolstered expertise in transgenics and analysis of genes. With the turn of the millennium, the Department played a pivotal role in large-scale genome sequencing, contributing to the complete sequencing of the rice genome (2005), tomato genome (2012), and wheat genome (2019) as part of several international consortia. Our faculty maintains strong collaborations with leading international researchers through bilateral research programmes, providing young scientists with unparalleled opportunities to engage in world-class research and turn their aspirations into reality.

Faculty members have undertaken several research initiatives supported by major grants from DBT, DST, UGC, the European Commission, and the Rockefeller Foundation (in the area of the Centre for Plant Molecular Biology, Genome Sequencing Initiatives, and Functional Genomics). Faculty members actively participate in multi-institutional and international collaborations, producing 900+ publications in high-impact journals such as *Nature, Genome Research, Nucleic Acids Research, Trends in Biotechnology, Trends in Plant Science, Plant Journal, Plant Physiology, Plant Biotechnology Journal, New Phytologist, Journal of Experimental Botany, Plant Cell & Environment, and Bioessays,* along with several patents. Their contributions have been recognized through national and international fellowships and awards.

While emphasizing fundamental research and training, the Department is committed to translational applications for human welfare. Its alumni hold key positions in academia and research institutions in the country and worldwide, including Washington State University; University of Nebraska, Lincoln; Texas Tech University Health Sciences Centre Rothamsted Research Station), Guru Jambheshwar University (Hisar), Bioseed Research (Hyderabad), ICAR-IARI, ICGEB, BRIC-NIPGR, JNU, IIT Delhi, BRIC-NII, Indraprastha University, IISER (Bhopal), TERI University, CIMAP (Lucknow), Birsa Agricultural University (Ranchi) and Assam Agricultural University (Jorhat), BITS (Hyderabad), NABI (Mohali), University of Hyderabad, among others. Many lead research groups in both academia and industry, contributing significantly to the advancement of plant molecular biology.

II. Introduction to NEP Programme

Scope

The National Education Policy (NEP) 2020 aims to transform post-graduate education by introducing flexibility, interdisciplinary, and skill-oriented learning. The program is structured to equip students with advanced knowledge and specialized skills, preparing them for research and innovation. The key features of this program include flexible program structure, interdisciplinary learning, multiple entry and exit points, credit mobility, focus on emerging fields, skill-based learning, continuous assessment, and emphasis on research and skill development. NEP2020 modernizes post-graduate education by making it flexible, industry-aligned, and student-centric, empowering learners to shape their academic journey in line with their interests and career aspirations.

Definition of Keywords

i. **"Discipline Specific Core (DSC)"** means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course. DSCs shall be the core credit courses of that particular discipline which will be appropriately graded and arranged across the semesters of study, being undertaken by the student, with multiple exit options as per NEP 2020.

ii. **"Discipline Specific Elective (DSE)"** shall be a pool of credit courses of that particular discipline (single discipline programme of study) or those disciplines (multidisciplinary programme of study), as the case may be, which a student chooses to study from his/her particular discipline(s). This course is to be selected by a student out of such courses offered in the same or any other Department/Centre of FIAS.

iii. **“Generic Electives (GEs)”** are a pool of courses which is meant to provide multidisciplinary or interdisciplinary education to students**.** various disciplines of study (excluding the GEs offered by the parent discipline), in groups of odd and even semesters, from which a student can choose. The concerned Department would identify the GEs specified in the framework as GEs to be taught in a Programme.

iv. **“Skill Enhancement Courses** (**SEC)”** are skill-based courses in all disciplines aimed at providing students with hands-on training, competencies, proficiency and skills. SEC courses may be chosen from a pool of courses designed to provide skill-based instruction.

v. **“Dissertation”** means a research project completed and written as part of a postgraduate degree

vi. **“Credit”** is a unit by which the coursework is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.

vii. **“SGPA”** is the Semester Grade Point Average calculated for individual semesters.

viii. **“CGPA”** is the Cumulative Grade Point Average calculated for all courses completed by the students at any time. CGPA is calculated each year for both semesters clubbed together.

ix. **“Grand CGPA”** is calculated in the last year of the course by clubbing together CGPA of two years, i.e., four semesters. Grand CGPA is given in the transcript form. To benefit the student a formula for conversion of Grand CGPA into %age marks is given in the Transcript.

III. M.Sc. PMBB Programme Details

The **M.Sc. Programme in Plant Molecular Biology and Biotechnology (PMBB)** at the Department of Plant Molecular Biology Department (PMB), University of Delhi South Campus (UDSC), offers an enriching and dynamic learning experience at the forefront of modern Plant Sciences. Designed to keep pace with cutting-edge advancements, this program equips students with the expertise needed for a potential career in Plant Molecular Biology and allied fields. With a meticulously structured curriculum, the PMBB program nurtures future-ready researchers and skilled professionals, bridging the gap between academia and industry. Graduates of this program are well-positioned to contribute to leading research institutions and drive innovation in the rapidly growing Plant Biotechnology sector, both in India and abroad.

Our comprehensive curriculum encompasses Classroom Teaching, Laboratory Practical sessions, Tutorials in the form of Seminars, and an invigorating Dissertation component. Throughout the course, students will explore courses on Discipline Specific Core, Discipline Specific Elective, Generic Elective, Advanced Research Methodology /Tools for Research, Techniques of Research Writing and Skill-based papers intelligently distributed across four Semesters. These courses will be taught within the PMB Department, while the students will have the opportunity to choose from a diverse array of topics offered by sister Departments within the Faculty of Interdisciplinary and Applied Sciences (FIAS) at UDSC for the remaining paper(s).

The journey begins in the **first semester** with three core Papers from the PMB Department, delving into the Basics of Genetics and Molecular Biology, Molecular Cell Biology, and Recombinant DNA technology. Additionally, the course also offers three elective courses focusing on advanced subjects: Model Organisms in Molecular Biology Research, Plants in Human Health and Nutrition, and Laboratory Instrumentation & Safety. Students have a choice to select any two of the three DSE papers offered, or they can also select one of the DSE offered by PMB and any one Generic Elective (GE) paper offered by other departments of FIAS. The students will also be introduced to Biological Data Analysis and Interpretation as their SEC paper in the first semester itself. Notably, a paper on Model Organisms in Molecular Biology Research is open to students from other FIAS Departments too, adding to the interdisciplinary learning experience. The DSEs, Biological Data Analysis and Interpretation, and SEC papers provide an opportunity to delve deeper into specialized areas and expand the knowledge base.

In the **second semester**, students will dive into three captivating DSC Papers exploring the Molecular Basis of Plant Development, Plant Biochemistry and Metabolism, Eukaryotic Gene expression and regulation and either any two of the DSE papers offered (Proteomics, and Metabolomics, Cell Signaling, Plant-Environment Interaction) or one DSE offered by PMB and one GE offered by other departments of FIAS. Notably, a paper on Proteomics and Metabolomics is also open to students from other FIAS Departments.

The **third semester** brings an advanced DSE Paper to the forefront, Plant Molecular Biology and Biotechnology, and two DSE papers, Crop Biotechnology and Advanced Plant Imaging. Moreover, students will get an opportunity to learn the skills of Bioinformatics as they will be taught two skill-based courses in the same semester: Computational Biology - I and Bioinformatics.

In the **final semester**, the PMB department offers two DSE papers: Data Analytics and Biocuration, Epigenetics and Small RNA Biology, and a two-credit course on Science communication and presentation. Complementing all the DSC papers and most of the DSE papers, hands-on Practical sessions are thoughtfully designed to provide students with real-world experience, while Tutorials empower students to sharpen their presentation skills. The third and fourth semesters will focus on applying the ideas more practically and hands-on, especially through dissertations. This can be an exciting time to really dive deep into students' areas of interest and put theory into practice, which will embark on an immersive research journey under the guidance of esteemed faculty members. This experience will equip you with invaluable skills and direct exposure to conducting cutting-edge research in a modern laboratory environment.

PMBB Programme Details

i. **Programme Objectives (POs):** The M.Sc. Course in Plant Molecular Biology and Biotechnology at the Department of Plant Molecular Biology (PMB), UDSC, has been designed to provide students with comprehensive exposure to the latest advancements in the exciting and burgeoning areas of modern Plant Sciences. This program equips students with the necessary theoretical knowledge and practical skills to pursue cutting-edge research in Plant Molecular Biology and related disciplines. Additionally, it aims to develop a skilled workforce capable of contributing to the rapidly growing Plant Biotechnology industry, opening avenues for careers in academia and industry.

ii. **Programme Specific Outcomes (PSOs):** After successfully completing the program, students will have developed a comprehensive and in-depth understanding of plant systems at the molecular level. They will gain a clear and precise grasp of how plants respond at the molecular level to various environmental and developmental cues. In addition to building a strong theoretical foundation, students will acquire essential practical skills, encompassing both wet-lab techniques and computational analyses. This well-rounded training will equip them with the expertise necessary to undertake challenging research projects in their future careers. Furthermore, they will gain insights into the complexities of molecular engineering and its applications in developing improved crop varieties. The program is designed to equip students with the knowledge and skills required to meet the criteria for conducting research in line with the BioE3 (Biotechnology for Economy, Environment, and Employment) Policy of the Government of India. By integrating advanced biotechnological approaches with principles of environmental sustainability, students will be prepared to contribute to innovative solutions that address the growing global demand for food and agricultural resilience.

iii. **Programme Structure**: The M.Sc. in Plant Molecular Biology and Biotechnology (PMBB) is a one/or two-year programme offering a comprehensive and structured curriculum designed to provide both fundamental knowledge and advanced expertise in the field. The program includes:

- **DSCs (4 credits each)** establish a strong foundation, ensuring students gain up-to-date concepts in plant molecular biology and biotechnology.
- **DSEs discipline or internal elective papers (4 credits each)** offer advanced and in-depth exploration of specific topics that build upon concepts introduced in the

core papers. These electives also incorporate substantial hands-on training to enhance practical understanding and research skills.

- **GEs (4 credits)** are designed to provide specialized knowledge and practical insights in an emerging area of biological sciences, accessible to a broader cohort of life sciences students.
- **SECs (2 credits each)** are tailored to provide practical, industry-relevant, and research-driven skills that prepare students for both academia and industry.
- **Three papers of 2 credits each** focus on the advanced research methods of the core discipline, basic and advanced research tools, and research writing techniques.
- **A dissertation (12/26 credits)** is structured to engage students in independent research, develop problem-solving skills, and contribute to scientific advancements in the field.

The well-balanced curriculum ensures that graduates acquire both theoretical expertise and practical proficiency, equipping them for careers in academic research, biotechnology industries, and related scientific fields.

Semester-wise Programme Structure

The M.Sc. The Plant Molecular Biology and Biotechnology program is a two-year course divided into four semesters. A student is required to complete eighty-eight credits to complete the course and be awarded a degree. A student has to accumulate twenty-two credits in each of the four semesters. The program structure is based on the Post Graduate Curricular Framework under NEP-2020. Under PGCF-NEP2020, in the first year of the program, the student is required to study mandatory Discipline Specific Core courses (three DSCs in each semester) and a total of four Discipline Specific Elective courses (two DSEs in each Semester). In lieu of one DSE in each Semester, the student may choose to study a General Elective course offered by any other Department of FIAS. In addition, the student will also be required to study one mandatory skill-based practical course (SBC) each semester of the first year. In the second year of the program, the student will have an option to choose any one of the three structures, which are: Structure 1 (PG with only coursework), Structure 2 (PG with coursework and research), or Structure 3 (PG with research). The details regarding these structures have been summarized in tabular form.

Course Credit Scheme

Two-Year PG Course Credit Scheme

Structure-1 (Level 6.5): (PG with only coursework)

Semester	Core Courses		Elective courses		Skill-based course/ Hands on Learning		Research Methods/ Tools/ Writing		Dissertation/ Project		Total Credits
	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	3	12	1	2	-	-	-	-	22
IV	2	8	3	12	1	2	-	-	-	-	22
Total Credits	**40**		**40**		**8**		**-**		**-**		**88**

Structure-2 (Level 6.5): (PG with coursework and research)

Semester	Core Courses		Elective courses		Skill-based course/ Hands on Learning		Research Methods/ Tools/ Writing		Dissertation/ Project		Total Credits
	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	2	8	-	-	-	-	1	6	22
IV	2	8	2	8	-	-	-	-	1	6	22
Total Credits	**40**		**32**		**4**		**-**		**12**		**88**

Structure-3 (Level 6.5): (PG with research)

Semester	Core Courses		Elective courses		Skill-based course/ Hands on Learning		Research Methods/ Tools/ Writing		Dissertation/ Project		Total Credits
	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	1	4	1	4	-	-	2	4	1	10	22
IV	-	-	1	4	-	-	1	2	1	16	22
Total Credits	**26**		**24**		**4**		**6**		**26**		**88**

SEMESTER-WISE PROGRAMME STRUCTURE

First-Year Course Details (Common in Structure 1, 2, and 3)

PART- I	Semester 1			
Name of the Course	Credits in Each Course			
	Theory	Practical	Tutorial	Total Credits
DISCIPLINE SPECIFIC CORE COURSES (DSC)				
PBSC101: Basic Molecular Biology and Genetics	3	1	0	4
PBSC102: Molecular Cell Biology	3	1	0	4
PBSC103: Recombinant DNA technology-Concepts, Techniques, and Applications	3	1	0	4
DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)*				
PBSE104: Plants in Human Health and Nutrition	3	1	0	4
PBSE105: Laboratory Instrumentation & Safety	3	1	0	4
PBSE106: Model Organisms in Molecular Biology Research	3	0	1	4
SKILL DEVELOPMENT COURSE				
PBSD107: Biological Data Analysis and Interpretation	1	1	0	2
TOTAL CREDITS IN SEMESTER 1				**22**

**PBSE106 is open to students of other departments as a GE course*

PART-I	Semester 2			
Name of the Course	**Credits in Each Course**			
	Theory	**Practical**	**Tutorial**	**Total Credits**
DISCIPLINE SPECIFIC CORE COURSES (DSC)				
PBSC201: Molecular Basis of Plant Development	3	1	0	4
PBSC202: Plant Biochemistry and Metabolism	3	1	0	4
PBSC203: Eukaryotic Gene expression and regulation	3	1	0	4
DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)*				
PBSE204: Cell Signalling and Communication	3	1	0	4
PBSE205: Plant-Environment Interaction	3	1	0	4
PBSE206: Proteomics, Metabolomics & Elementomics	3	0	1	4
SKILL DEVELOPMENT COURSE				
PBSD207: Plant Tissue Culture and Transformation Methodologies	0	2	0	2
TOTAL CREDITS IN SEMESTER 2				**22**

**PBSE206 is open to students of other departments as a GE course*

Second Year: Structure - 1 (PG with only coursework)

Semester-3

	Credits in each course			
Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Core (DSC) courses				
	3	1	0	4
	3	1	0	4
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
	3	1	0	4
	3	1	0	4
Generic Elective (GE) course*				
	3	0	1	4
Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning				
	0	2	0	2
Total credits			0	**22**

*(*a student can opt for either three DSE course, or two DSE with one GE*)

Semester-4

	Credits in each course			
Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Core (DSC) courses				
	3	1	0	4
	3	1	0	4
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
	3	1	0	4
	3	1	0	4
Generic Elective (GE) course*				
	3	0	1	4
Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning				
	0	2	0	2
Total credits				**22**

*(*a student can opt for either three DSE course, or two DSE with one GE*)

Second Year: Structure - 2 (PG with Coursework and Research)

Semester-3

	Credits in each course

Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Core (DSC) courses				
	3	1	0	4
	3	1	0	4
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
	3	1	0	4
Generic Elective (GE) course*				
	3	0	1	4
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
	0	6	0	6
Total credits				**22**

*(*a student can opt for either two DSE courses, or one DSE and one GE*)

Semester-4

	Credits in each course			
Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Core (DSC) courses				
	3	1	0	4
	3	1	0	4
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
	3	1	0	4
Generic Elective (GE) course*				
	3	0	1	4
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
	0	6	0	6
Total credits				**22**

*(*a student can opt for either two DSE courses, or one DSE and one GE*)

Second Year: Structure - 3 (PG with Research)

Semester-3

	Credits in each course

Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Core (DSC) courses				
	3	1	0	4
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
Research Methods/ Tools/ Writing				
	2	0	0	2
	2	0	0	2
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
	0	10	0	10
Total credits				**22**

Semester-4

	Credits in each course			
Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
Research Methods/ Tools/ Writing				
	2	0	0	2
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
	0	16	0	16
Total credits				**22**

iv. Eligibility for Admissions

- A 3-year/6-semester bachelor's degree with a minimum of 120 credits for a 2-year/4-semester PG programme at level 6.5 on the National Higher Education Qualifications Framework (NHEQF).
- A bachelor's degree with Honours/ Honours with Research with a minimum of 160 credits for a 1-year/2-semester PG programme at level 6.5 on the NHEQF.
- A student is eligible for admission in PMBB PG programs if the student qualifies for the CUET(PG) or GAT-B Entrance Examination.
- Appropriate relaxation for candidates belonging to reserved categories is applicable as per the university norms.

v. Assessment of Students' Performance and Scheme of Examination

- The examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

vi. Pass Percentage & Promotion Criteria

- As per the UGC / University Examination rule.

vii. Conversion of Marks into Grades

- As per the UGC / University Examination rule.

viii. Grade Points

- As per the UGC / University Examination rule.

ix. CGPA Calculation

- As per the UGC / University Examination rule.

x. SGPA calculation

- As per the UGC / University Examination rule.

xi. Grand SGPA calculation

- As per the UGC / University Examination rule.

xii. Conversion of Grand CGPA into marks

- As per the UGC / University Examination rul**es.**

xiii. Conversion of Grand CGPA into marks

- As per UGC / University Examination rule.

xiv. Division of Degree into Classes

- As per the UGC / University Examination rule.

xv. Attendance Requirement

- As per the UGC / University Examination rule.

xvi. Span Period

- As per the UGC / University Examination rule.

xvii. Attendance Requirement

- As per the UGC / University Examination rule.

IV. Course-wise Content Details for the PMBB Programme

SEMESTER 1

PBSC101: Basic Molecular Biology and Genetics

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC101: Basic Molecular Biology and Genetics	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

The course aims to deliver in-depth knowledge of genomic stability, DNA replication, transcription, translation, and gene regulation, using prokaryotic model systems to the students. This course will also provide a deep understanding of genetic principles, from Mendelian inheritance to modern molecular genetics. Students will explore gene interactions, linkage, mapping techniques, and quantitative genetics. Through theoretical knowledge and analytical techniques, students will develop experimental and analytical skills in genetics and molecular biology.

Learning Outcomes

Upon completion, students will understand DNA replication, transcription, and translation processes, as well as gene regulation models. Students will have a strong foundation in classical and molecular genetics, enabling them to analyze genetic inheritance, gene mapping, and genome stability mechanisms. Students will develop skills in applying genetic analysis tools and interpreting experimental data. Students will learn methods to estimate point mutation, homologous recombination, and transposition. Further, students will acquire skills in cytogenetic techniques for chromosome analysis.

Course Content (45 hours)

Unit 1: Mechanism of Replication in Prokaryotes -- DNA polymerases and accessory proteins; Proteins at the origin of replication and replication fork; Concept of replicon; Fidelity of replication; Control of replication of chromosomes and extrachromosomal elements. 6 hours

Unit 2: Prokaryotic Transcription, Translation and its Regulation -- Discovery of RNA; Initiation of transcription: Promoters and other control elements; RNA polymerases and accessory factors; Sigma factors and their interactions with promoters; Transcriptional controls; Concept of operons; Transcription termination; Rho factor and polar mutations; Gene regulation in Bacteriophages: lysogenic and lytic cycles, regulation of gene expression; Initiation, elongation, and termination of translation and the accessory proteins; Structural and functional studies on ribosomes: ribosomal RNAs and proteins; Mapping the decoding and peptidyl transferase sites of ribosome; Transfer RNAs and genetic code; Translational fidelity. 16 hours

Unit 3: Mendelian Principles, Gene Mapping and Quantitative Genetics -- Introduction to Mendelian Genetics; codominance, incomplete dominance, gene interactions (epistasis), pleiotropy, penetrance and expressivity, linkage and crossing over, sex linkage, genome imprinting; Genetic and physical maps; Molecular markers: RFLP, RAPD, AFLP, SSR, SNP; Mapping genes by interrupted mating, polygenic inheritance, QTL (Quantitative trait locus) mapping, LOD (Logarithm of the Odds) score for linkage testing, pedigree analysis, karyotypes, tetrad analysis, Chi-square test in linkage analysis. 15 hours

Unit 4: Maintenance of Genomic Flexibility and Integrity -- Spontaneous and induced mutations; Mutagens; Mechanisms of homologous and site-specific recombination (NHEJ, HR, MMEJ); Mechanism of meiotic crossing-over; DNA repair and retrieval systems; Transposons and retro-transposons. 8 hours

Practicals (30 hours)

1. Extraction and analysis of genomic DNA from bacteria.
2. To perform bacteriophage plaque assay.
3. Study of frameshift mutation and homologous recombination by histochemical assays.
4. Visualization of chromatin structure using DAPI staining.
5. Analysis of cell ploidy by chromosomal counting at metaphase/flow cytometry.

Suggested Readings:

1. Clarke, D. and Pazdernik, N. (2013) Molecular Biology. Academic Cell, USA. ISBN: 9780123785947.
2. Griffiths, A., Wessler, S., Lewontin, R. and Carroll, S. (2007) Introduction to Genetic Analysis. W. H. Freeman, USA. ISBN: 9780716768876.
3. Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. (2013) Lewin's Genes XI. Jones and Bartlett Publishers, Inc., USA. ISBN: 9781284027211.
4. Tropp, B. E. (2014) Principles of Molecular Biology, Jones and Bartlett, USA. ISBN: 9781449689179.
5. Weaver, R. F. (2012) Molecular Biology. McGraw Hill, UK. ISBN: 9780073525327.
6. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2017). Lewin's genes XII. Jones & Bartlett Learning. ISBN: 1284104494

SEMESTER 1

PBSC102: Molecular Cell Biology

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC102: Molecular Cell Biology	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

This paper is designed to provide an in-depth understanding of cell biology, focusing on the molecular and biochemical processes that regulate cellular functions. A key emphasis is placed on the molecular organization of biological macromolecules and their role in forming distinct subcellular structures, enabling the precise coordination of essential cellular processes.

Learning Outcomes

Students would learn about the structure-function relationship of cellular organelles from a molecular perspective, focusing on macromolecules at both cellular and subcellular levels. Students will explore key molecular, biochemical, and imaging techniques employed for studying cells and cellular processes. By integrating mechanistic insights, this course will equip students with the knowledge to design strategies for manipulating cellular processes to address challenges in managing nutrition and food security.

Course Content (45 hours)

Unit 1: Investigating the Cell and Cell wall -- Fundamentals of microscopy and imaging, techniques for analyzing the cell and its organelles; Cell wall composition and architecture, biogenesis and assembly, dynamic aspects of the cell wall during growth and differentiation. 9 hours

Unit 2: Membrane and Endomembrane Systems -- Structural models, composition and dynamics; Transport of ions and macromolecules: transporters and channels; Sensory physiology; Endo- and exo-cytosis; Membrane proteins and carbohydrates and their significance in cellular processes; Structure and function of Golgi apparatus, lysosomes and endoplasmic reticulum and microbodies; Intracellular membrane trafficking and vesicular transport; Membrane maturation and specialization: extracellular vesicles, multivesicular bodies**,** Kajal bodies, dicing bodies, and cytoplasmic bodies. 20 hours

Unit 3: Mitochondria, **Chloroplast and Nucleus** – Structure; Organization; Structure-function relationship; Import and export of molecules; Biogenesis, origin and evolution; Structure and function (architecture); Chromatin organization and packaging: heterochromatin, euchromatin, nucleosomes; Nuclear envelope and nuclear pore complex, Import and export of molecules.

12 hours

Unit 4: Cytoskeleton and Cellular Motility -- Organization and role of microtubules and microfilaments; Actin-binding proteins and their significance; Molecular motors; Intermediate filaments. 4 hours

Practicals (30 hours)

1. High-resolution imaging of epidermal peel cells of *Arabidopsis thaliana*/ *Nicotiana benthamiana* under confocal microscope.
2. Transient expression of fluorescent-tagged protein via Agrobacterium-based infiltration of leaf epidermal cells.
3. Monitor the localization of fluorescent-tagged protein at the subcellular level under a confocal microscope.
4. Preparation and visualization of leaf protoplasts of *Arabidopsis thaliana*/*Nicotiana benthamiana*.
5. To study the pollen viability and the effect of calcium on pollen germination.

Suggested Readings:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2015) Molecular Biology of the Cell. Garland Publishing, Taylor & Francis Group, USA. ISBN: 9781315735368.
2. Buchanan, B. B, Gruissem, W., Jones, R.L. (2015) Biochemistry and Molecular Biology of the Plants. American Society of Plant Physiologists, USA. ISBN: 9780470714218.
3. Karp, J. G. (2019). Cell and Molecular Biology. John Wiley & Sons, USA. ISBN: 9781119598169.
4. Kleinsmith, L. J. and Kish, V. M. (1996) Principles of Cell & Molecular Biology. HarperCollins College Publishers, USA. ISBN: 978-0065004045.
5. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretsher, A., Ploegh, H., Amon, A., Martin, K. (2016) Molecular Cell Biology. Freeman & Co., USA. ISBN: 978-1464183393.
6. Ruzin, S. E. (1999) Plant Microtechnique and Microscopy. Oxford University Press, USA. ISBN: 9780195089561.

<u>Semester 1</u>

PBSC103: Recombinant DNA Technology - Concepts, Techniques, and Applications

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC103: Recombinant DNA Technology - Concepts, Techniques, and Applications	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

The course is designed to provide a comprehensive understanding of the principles, methodologies, and tools in recombinant DNA technology. This will familiarize students with advanced techniques in molecular biology and equip them with hands-on knowledge about genetic engineering tools. Furthermore, they will learn about the applications of recombinant DNA technology in agriculture, medicine, and industry, while addressing ethical, social and regulatory concerns. The course will prepare students for research and innovation in emerging fields such as synthetic biology, metabolic engineering and genome editing. It will also provide a foundation to help students in developing advanced knowledge for succeeding semesters.

Learning Outcomes

The candidate will develop an in-depth knowledge of principles and applications of the instrumentation, basic and cutting-edge tools and techniques in recombinant DNA technology. Students will get acquainted with designing/conducting, and analyzing experiments and experimental data, respectively. Integration of theory and problem-solving exercises will motivate students to take a keen research interest and enhance their understanding of the topics they are taught. They will be able to evaluate the impact of recombinant DNA technology in agriculture, healthcare, and industry. The course will enable students to develop innovative solutions in genetic engineering, synthetic biology and protein engineering for real-world challenges.

Course Content (45 hours)

Unit 1: **Introduction to Recombinant DNA Technology** -- Historical perspectives and milestones; Basic principles and concepts; Methods of nucleic acids and protein analysis: Isolation and purification, electrophoresis techniques; Overview of genetic engineering tools. 6 hours

Unit 2: DNA Cloning Methodologies and PCR -- Key enzymes: restriction endonucleases, nucleic acid modifying enzymes; Advanced cloning methods: TA cloning, topoisomerase-based cloning, ligation-independent cloning, Gateway technology, Gibson cloning; Vectors for gene cloning: plasmids, phages, phagemids, cosmids, and other advanced vectors for cloning large DNA fragments; Methods for selection and screening of recombinant clones; Host systems: bacteria, yeast, and plant cells; Isolation of gene of interest: Direct selection, construction and screening of genomic and cDNA libraries, labelling and detection of nucleic acids, enriching clones by subtractive cloning and differential screening, differential display; Polymerase Chain Reaction (PCR) : concept and enzymes employed, optimization of PCR, types of PCR (touch-up, touch-down, hot-start, inverse, nested, gradient, Rapid Amplification of cDNA Ends (RACE), semi-quantitative and quantitative, Gene Splicing by Overlap Extension (gene SoEing), and applications of PCR; DNA sequencing methods. 15 hours

Unit 3: Methods to Study Gene Expression and Biomolecular Interactions and Protein Expression Systems -- Gene expression analyses at the transcriptional level (Northern blotting and its variants, real-time PCR, S1 nuclease mapping, *in situ* hybridization, RNase protection, nuclear run-on assays), translational level: Western blotting, Enzyme-Linked ImmunoSorbent Assay (ELISA) and immunofluorescence assays; DNA-protein: Electrophoretic Mobility Shift Assay (EMSA), DNase I footprinting, Chromatin ImmunoPrecipitation (ChIP), Yeast one-hybrid (Y1-H), RNA-protein: Y3-H, northwestern, RNA ImmunoPrecipitation (RIP); protein-protein interaction: Y2-H, pull down, Co-ImmunoPrecipitation (Co-IP), Fluorescence Resonance Energy Transfer (FRET), Bimolecular Fluorescence Complementation (BiFC); Protein Expression and Engineering: Tagging and overexpression of proteins in heterologous systems (*E. coli*, yeast, baculovirus, and mammals); Methods for mutagenesis of genes for obtaining altered proteins.

15 hours

Unit 4: Applications and Ethics of Recombinant DNA Technology -- Production of recombinant molecules for improving agronomic traits, diagnostic and therapeutic applications in human diseases; Impact and biosafety, moral, social, regulatory and ethical concerns; Future perspectives and emerging trends (introduction to gene editing, synthetic biology, and genome engineering, the role of artificial intelligence or AI, etc.) 9 hours

Practicals (30 hours)

1. Transformation of bacterial competent cells followed by blue-white screening for identification of recombinant plasmid.
2. Colony PCR for screening of recombinant plasmids.
3. Isolation of plasmid DNA from *E. coli* culture and quantitation of DNA.

4. Restriction digestion of plasmid DNA and resolution of the digested DNA by agarose gel electrophoresis.
5. Induction of protein expression in a heterologous bacterial system and analysis of the expressed protein using SDS-PAGE.

Suggested Readings:

1. Brown, T. A. (2020) Gene Cloning and DNA Analysis: An Introduction. 8th edition. Wiley-Blackwell Publishing, UK. ISBN: 9781119640783.
2. Brown, T.A. (2024) Genomes 5. 5th edition. CRC Press, India. ISBN: 9780367674076.
3. Dale J. W., Schantz M. V. and Plant N. (2011) From Genes to Genomes: Concepts and Applications of DNA Technology. 3rd edition. John Wiley & Sons, UK. ISBN: 9780470683859.
4. Glick B. R. and Patten C. L. (2022) Molecular Biotechnology: Principles and Applications of Recombinant DNA. 6Th edition. ASM Press, USA. ISBN: 9781683673668.
5. Watson, J.D, Caudy, A., Myers, R.M. and Witkowski, J. (2006) Recombinant DNA: Genes and Genomes. 3rd edition. W.H. Freeman & Co, India. ISBN: 9780716728665.
6. Green M. R. and Sambrook J. (2012) Molecular Cloning: A Laboratory Manual. 4th edition. CSHL Press, USA. ISBN: 9781936113422.
7. Primrose, S. B. and Twyman, R. M. (2006) Principles of Genetic Manipulation and Genomics. 7th edition. Blackwell Publishing, UK. ISBN: 9781405135443.

<u>**Semester 1**</u>

PBSE104: Plants in Human Health and Nutrition

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSE104: Plants in Human Health and Nutrition	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

Plants play a crucial role in human health and nutrition by providing essential nutrients, bioactive compounds, and medicinal properties that support our well-being. The course aims to highlight the role of plants in human health and nutrition and explore the molecular basis of bioactive compounds in plants. The students will gain knowledge of plant-derived pharmaceuticals, nutraceuticals, and functional food. Furthermore, strategies for improving plant nutrition and ethical issues will be taught.

Learning Outcomes

The students will be able to understand the role of plants in human life, analyse functional foods and nutraceuticals. They will be able to comprehend the molecular basis of phytochemical synthesis and explore the plants as pharmaceuticals. Utilizing this knowledge, the students will be able to design innovative and novel strategies for plant biofortification and metabolic engineering to develop novel plant-based foods and sustainable nutritional and drug resources.

Course Content (45 hours)

Unit 1: Role of Plants in Human Health and Nutrition -- Plants in human health from biochemical perspective; History of plant-based nutrition and medicinal plants; Role of secondary metabolites in human health; Molecular basis of bioactive compounds and biosynthetic pathways.

10 hours

Unit 2: Plant-based Nutraceuticals and Medicine Systems -- Phytochemicals, Traditional and non-traditional nutraceuticals; Plant-derived probiotics and prebiotics; Biotechnological approaches for biofortification for enhanced nutrition; Plant-based Medicine Systems: Traditional knowledge and ethnobotany; Ayurvedic, Yoga, Unani, Siddha, and Homeopathic (AYUSH), other traditional systems; Modern systems of plant-based medicine and their importance in human health.

15 hours

Unit 3: Plants as Source of Pharmaceuticals -- Medicinal plants; Traditional plant-based formulations; Plant-derived molecules in drug development; Therapeutic use of poisonous plants; Pharmacogenomics; Ayurgenomics; Metabolic engineering for enhanced bioactive production; Good manufacturing practices (GMPs). 10 hours

Unit 4: Recent Advancements in Plant Science and Health – Plant vaccines; plant-focused biomanufacturing; DNA fingerprinting and barcoding of medicinal plants; synthetic biology for producing plant-derived therapeutic agents; plant-based meat alternatives and sustainable food sources; the role of microgreens and lower plants in nutrition; climate change and its impact on beneficial plant compounds; future perspectives and challenges; ethical and regulatory guidelines. 10 hours

Practicals (30 hours)

1. Pharmacognostic evaluation (macroscopic and microscopic) of medicinal plants.
2. Qualitative analysis of secondary metabolites: Alkaloids, Flavonoids, Tannins, Glycosides, Protein and Saponins, etc.
3. Quantitative analysis of secondary metabolites: Alkaloids, Phenolic Compounds, Flavonoids.
4. Perform chromatographic analysis of plant extracts.
5. Survey of medicinally important plants.

Suggested Readings:

1. Kumar, S., Dikshit, H.K., Mishra, G. P., Singh, A. (2022) Biofortification of staple crops. Springer NAture Singapore Pte Ltd. ISBN: 9789811632792.
2. Crozier, A., Clifford, M.N., Ashihara, H. (2006) Plant secondary metabolites: occurrence, structure and role in the human diet. Blackwell Publishing Ltd. ISBN: 9781405125093.
3. Simopoulos, A.P., Gopalan, C. (2003) Plants in Human Health and Nutrition Policy, Volume 91. ISBN: 3805575548.
4. The Ayurvedic Pharmacopoeia of India, Part I, Part II, Vol I- Vol III. Council for Research in Ayurvedic Sciences (*CCRAS).*
5. Database on Medicinal Plants used in Ayurveda and Siddha, Vol I- Vol VIII, Central Council for Research in Ayurvedic Sciences (*CCRAS).*
6. Chowdhury, S.R. (2023) Textbook of Food Science and Nutrition. Aaraban Publishers. ISBN:9789387270084.
7. Mudambi, R. S. and Rajagopal, M.V (1983) Foods and Nutrition. Wiley Eastern Ltd. Second Edition, New Delhi. ISBN: 9780852265833.
8. Keservani, R. K. (2024) Plant Metabolites and Vegetables as Nutraceuticals. Academic Press. ISBN: 9781774915448.
9. Usman, S., Budhrani N. (2020) Textbook of Plant Biotechnology. S Vikas and Company (PV).
10. Bharti, P. K. (2018) Nutraceuticals and Pharmaceutical from Medicinal Plants, Discovery Publishing House Pvt. Ltd. ISBN: 9789386841551.

Semester 1

PBSE105: Laboratory Instrumentation and Safety

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSE105: Laboratory Instrumentation and Safety	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

The course aims to equip students with a comprehensive understanding of the essential laboratory instruments used in molecular biology, biotechnology, and related fields. It is designed to expose them to best practices and regulatory compliance necessary for maintaining a safe and efficient research environment.

Learning Outcomes

Students will understand the principles, operation, and applications of various laboratory instruments. They will develop proficiency in instrument calibration, maintenance, and troubleshooting to ensure accuracy and reliability in experimental outcomes. Students will gain hands-on experience with state-of-the-art laboratory equipment, preparing them for advanced research and industrial settings. They will also develop a strong understanding of laboratory best practices, including biosafety measures, waste disposal, and emergency response protocols.

Course Content (45 hours)

Unit 1: Introduction to Laboratory Safety and Waste Management -- Laboratory safety guidelines: safety rules, biosafety levels (BSL1-BSL4), handling biological specimens; Chemical, biological, and radiation safety: chemical and biological material labelling and inventory management; Chemical/non-chemical storage guidelines, transportation and usage precautions, chemical hazard and safety datasheets, safe handling of carcinogens, mutagens, and toxic chemicals, Compressed gas cylinders and liquid cryogen containers; Biosafety cabinets and laminar airflow systems; Emergency preparedness and waste management: fire hazards, first-aid procedures for chemical spillage and exposure; Hazardous waste minimization and accumulation rules; Disposal of infectious or biological waste, including GMOs (modified microbes, transgenic plants). 15 hours

Unit 2: Radiological Laboratories and Radiation Safety -- Nature of Radioactivity, biological effects of Ionizing Radiation, operational radiation exposure limits, radiation hazard evaluation and control, planning of radioisotope laboratories, regulatory aspects of radioisotope laboratories, disposal of radioactive waste. 8 hours

Unit 3: Essential Laboratory Instrumentation -- Operation, principles, calibrations, maintenance, and applications of general instruments: weighing balances, pH meter, autoclave, centrifuges, electrophoresis, spectrophotometers (UV-Vis and nanodrop), fluorometers, thermal cyclers (PCR, digital droplet PCR, and real-time PCR machines), incubators/shakers, chromatography, gel documentation system, phosphor imaging systems, Sanger sequencing instrumentation and techniques. 10 hours

Unit 4: Advanced Instrumentation in Plant Molecular Biology Research -- Electroporators**,** Surface Plasmon Resonance (SPR) Systems, Isothermal Titration Calorimeter, (ITC), BioLayer Interferometry (BLI), *in vivo* imaging system, phytotrons and greenhouses, photosynthesis measurement systems, Flow cytometry: fluidic system, optical system, signal detection and processing system, Fluorescent-Activated Cell Sorting (FACS); High-throughput plant phenomics systems, smart remote agriculture monitoring systems (Internet of Things or IoT-based monitoring, AI-based precision monitoring, data loggers). 12 hours

Practicals (30 hours)

1. Precision measurement and liquid handling using micropipettes.
2. Preparation of molecular biology reagents and buffers.
3. Colorimetric analysis of different biomolecules using spectrophotometer.
4. Differential centrifugation for separation of cell organelles.
5. Demonstration of Sanger sequencing technology and flow cytometry instrument.

Suggested Readings:

1. Brown, T.A. (2023). Essential Molecular Biology: A Practical Approach. ISBN: 9781383049282.
2. Wilson, K., Hofmann, A., Walker, J.M., & Clokie, S. (Eds.). (2018). Wilson and Walker's principles and techniques of biochemistry and molecular biology. Cambridge University Press. ISBN: 9781316677056, DOI: 10.1017/9781316677056.
3. Green M. R. and Sambrook J. (2012) Molecular Cloning: A Laboratory Manual. 4th edition. CSHL Press, USA. ISBN: 9781936113422.
4. McKinnon, K.M. (2018). Flow cytometry: an overview. Current protocols in immunology, 120(1), 5-1. doi.org/10.1002/cpim.40.
5. Doležel, J., Greilhuber, J., & Suda, J. (2007). Estimation of nuclear DNA content in plants using flow cytometry. Nature Protocols, 2(9), 2233-2244. doi.org/10.1038/nprot.2007.310.

<u>Semester 1</u>

PBSE106: Model Organisms in Molecular Biology Research

<u>This course is open to students of other departments as a GE course</u>

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSE106: Model Organisms in Molecular Biology Research	4	3	1	0	B.Sc. in any branch of Science	NA

Learning Objectives

Model organisms have a pivotal role in advancing our understanding of fundamental biological processes. The course aims to provide an in-depth understanding of the significance of model organisms in molecular biology research. It will familiarize students with the criteria for selecting model organisms and the diversity of models used across different biological kingdoms. It will provide an opportunity to examine the unique features, advantages, and limitations of various model systems. Information will be imparted on emerging model organisms and non-model organisms with unique features and cutting-edge advancements such as artificial cell models. Ethical considerations will be discussed to ensure responsible research practices.

Learning Outcomes

Students will be able to understand the importance of model organisms and their contribution to molecular biology research in different fields. They will be able to evaluate and select appropriate model systems for specific research objectives and explore the utility of emerging model systems and novel technologies in advancing molecular biology research. Students will be aware of ethical issues and guidelines for humane and sustainable research involving model organisms.

Course Content (45 hours)

Unit 1: Introduction to Model organisms -- Fundamental concepts and importance of model organisms in molecular biology research, criteria for selecting model organisms, types of model organisms across different phyla, historical milestones, comparative overview between prokaryotic and eukaryotic model systems; Nobel prize-winning discoveries utilizing model organisms. 7 hours

Unit 2: Prokaryotic and Lower Eukaryotes Models -- Importance and utility of prokaryotic models and their genetic manipulation (e.g. *Escherichia coli, Bacillus subtilis, etc.*); Bacteriophages; Lower eukaryotes: Importance and utility of unicellular eukaryotes and their genetic manipulation; yeast (*Saccharomyces cerevisiae*, *Schizosaccharomyces pombe*); *Neurospora crassa*; *Dictyostelium discoideum.* 15 hours

Unit 3: **Animal and Plant Models** -- Importance and utility of animal models and their genetic manipulation, Vertebrates (*Mus musculus, Rattus norvegicus, Danio rerio, Xenopus laevis, Macaca* spp. and other primates), Invertebrates (*Drosophila melanogaster, Caenorhabditis elegans*), cell lines as *in vitro* models, human disease models; Plant Models: Importance and utility of plant models and their genetic manipulation, lower plants (microalgae for biofuels: *Chlorella vulgaris*, *Botryococcus braunii*, *Chlamydomonas reinharditii*, *Marchantia*, *Physcomitrella*); Monocots (*Oryza sativa*, *Brachypodium distachyon, Panicum spp.,* other models); Dicots (*Arabidopsis thaliana*, *Medicago truncatula*, *Jatropha curcas*, and other models). 15 hours

Unit 4: Emerging Model Organisms and Ethics -- Non-model species with unique features, such as Tardigrades, Axolotls, *Octopus bimaculoides*; Advances in model research: development of artificial cell models, other pioneering studies for insights into untapped species and their potential applications; Ethical considerations: animal welfare, regulatory guidelines, ethical issues, alternatives to animal models (such as organoids, *in silico* simulations, and integration of AI and computational models). 8 hours

Tutorials (15 hours)

Suggested Readings:

1. Ankey, R.A. and Leonelli S. (2021) Model organisms. Cambridge University Press. ISBN: 9781108742320.
2. Emerging model organisms: A Laboratory Manual Vol 1 (2009) Cold Spring Harbor Laboratory Press. ISBN: 978-0879698720.
3. Jarret, R.L and McCluskey, K. (2020) Biological resources of model organisms. 1st edition CRC Press. ISBN: 9781138294615.
4. Davis, R H. (2003) The Microbial Models of Molecular Biology: From Genes to Genome. OUP Oxford Press. ISBN: 9780195154368.
5. Tang B, Wang Y, Zhu J, Zhao W. (2015) Web resources for model organism studies. Genomics Proteomics Bioinformatics. 13(1), 64-68. DOI: 10.1016/j.gpb.2015.01.003.
6. Latest research and review articles from Scientific journals and book chapters.

Semester 1

PBSD107: Biological Data Analysis and Interpretation

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSD107: Biological Data Analysis and Interpretation	2	1	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

This course provides an in-depth understanding of the fundamental and advanced research methodologies employed in plant molecular biology and biotechnology. It focuses on experimental design, data analysis, and scientific communication while integrating guest lectures of specialists (if required). Special emphasis will be given to high-throughput sequencing, genome editing, plant transformation techniques, and bioinformatics approaches relevant to molecular plant sciences.

Learning Outcomes

Upon completion of this course, students will be adept at designing robust biological experiments, performing comprehensive statistical analyses, and interpreting various data types with scientific rigor. They will gain proficiency in hypothesis testing, regression models, and survival analysis while understanding ethical concerns in biostatistics. Learners will acquire knowledge to analyze transcriptomic data using tools like DESeq2 and DAVID. Additionally, they will develop the ability to create effective, publication-quality visualizations of complex biological datasets.

Course Content

(Lectures combined with problem-solving practical sessions; 15+30 = 45 hours)

Unit 1: Experimental Design and Biostatistics -- Principles of experimental design; control groups, replication, and randomization; types of biological data and measurement scales; descriptive statistics (mean, median, variance, standard deviation); probability distributions (normal, binomial, Poisson); hypothesis testing (t-tests, chi-square, ANOVA, non-parametric tests); power analysis and sample size determination; ethical considerations in biostatistics;

6 hours

Unit 2: Gene expression analysis and Data Visualization -- Overview of transcriptomics; RNA sequencing (RNA-Seq), microarrays; data preprocessing (quality control, normalization, transformation); differential gene expression analysis; functional enrichment, pathway analysis; visualization techniques (heatmaps, volcano plots, expression profiles); case studies; hands-on analysis using tools like DESeq2, edgeR, STRING, DAVID. Principles of effective data visualization; types of visualizations (bar plots, scatter plots, box plots, heatmaps); visualization of complex biological data (networks, phylogenetic trees, multidimensional plots); best practices for scientific presentations and publications. 9 hours

Practicals (30 hours)

1. Design an experiment (e.g., drug effect on bacteria) and identify variables, control groups, and the method of randomization.
2. Analyze sample datasets (e.g., plant development-based measurements during stress responses); Classify data and discuss implications for statistical tests.
3. Run t-tests, chi-square tests, and ANOVA on the provided datasets.
4. Identify genes differentially expressed across conditions (using microarray or NGS datasets) and interpret results (using log2 fold changes, p-values, adjusted p-values).

Suggested Readings:

1. Quinn, G. P., & Keough, M. J. (2002). Experimental Design and Data Analysis for Biologists. Cambridge University Press. ISBN: 978-0521009768.
2. Heath, D. (1995). An Introduction to Experimental Design and Statistics for Biology. UCL Press. ISBN: 978-1857281323.
3. Welham, S. J., Gezan, S. A., Clark, S. J., & Mead, A. (2015). Statistical Methods in Biology: Design and Analysis of Experiments and Regression. CRC Press. ISBN: 978-1032918327.
4. Daniel, W. W., & Cross, C. L. (2018). Biostatistics: A Foundation for Analysis in the Health Sciences (11th ed.). Wiley. ISBN: 978-1118302798.
5. Barah, P., Bhattacharyya, D. K., & Kalita, J. K. (2021). Gene Expression Data Analysis: A Statistical and Machine Learning Perspective. CRC Press. ISBN: 978-0367338893.
6. Parmigiani, G., Garrett, E. S., Irizarry, R. A., & Zeger, S. L. (2003). The Analysis of Gene Expression Data: Methods and Software. Springer. ISBN: 978-0387955773.
7. Rangayyan, R. M. (2004). Biomedical Image Analysis. CRC Press. ISBN: 978-0849396953.
8. Hartvigsen, G. (2021). A Primer in Biological Data Analysis and Visualization Using R. Columbia University Press. ISBN: 978-0231202138.

Semester 2

PBSC201: Molecular Basis of Plant Development

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC201: Molecular Basis of Plant Development	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

The objective of this course is to provide an in-depth understanding of plant differentiation, development, and regulatory mechanisms. Students will explore key concepts such as totipotency, organogenesis, and tissue differentiation, along with light perception, plant growth, leaf and root development, floral induction, and reproductive processes. The course also covers the hormonal and molecular control of plant development, including seed development, dormancy, germination, senescence, and programmed cell death.

Learning Outcomes

Upon completion, students will have a comprehensive understanding of plant growth and developmental processes, from cellular differentiation to reproductive mechanisms. They will be able to analyze the molecular and genetic regulation of plant responses to environmental signals, particularly light. Students will gain expertise in light and hormonal control of plant development. Students will develop the skills to analyze the developmental stages of microspores and embryos. The course will enhance their ability to conduct research in plant biology and apply knowledge in crop improvement.

Course Content (45 hours)

Unit 1: Plant Differentiation and Photomorphogenesis -- Totipotency, meristems, organogenesis, adventive somatic embryogenesis, apomixis, trichome and stomata; phloem and xylem differentiation; gametogenesis and embryogenesis; Skotomorphogenesis and photomorphogenesis; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants. 14 hours

Unit 2: Leaf and Root Development -- Molecular basis of leaf development and polarity establishment; Venation patterns in leaves; Shoot branching and architecture; Hormonal control of leaf development; Stomatal development and movement; Phyllotaxy. Root apical meristem

(RAM), Primary and secondary root development, Root hair and Root system architecture (RSA), hormonal control of root development. 12 hours

Unit 3: Floral Induction and Regulation of Gametogenesis and Embryogenesis -- Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation: floral development in *Arabidopsis* and *Antirrhinum*; Formation of male and female gametes, pollination and fertilization; Self incompatibility; Cytoplasmic inheritance; Epigenetic imprinting; Embryo formation and cell lineage development in *Arabidopsis* and Maize. 8 hours

Unit 4: Seed Development, Dormancy, Germination and Programmed Cell Death (PCD) -- Seed maturation and dormancy; Hormonal control of seed germination, development, and seedling growth; Mobilization of food reserves during seed germination; Cell death, PCD, and apoptosis; Senescence in plants and its regulation; PCD during seed development, leaf development, and reproductive development; Energy and oxidative metabolism during senescence; Hormonal and environmental control of senescence. 11 hours

Practicals (30 hours)

1. Study of photomorphogenesis and skotomorphogenesis (by using mutant).
2. Analysis of microspore development.
3. Study of root differentiation using cytokinin markers.
4. Estimation of chlorophyll degradation during leaf senescence.
5. Study of embryo development.

Suggested Readings:

1. Gilbert, S. F. (2000) Developmental Biology. INC Publishers, USA. ISBN: 9780197699782.
2. Westhoff, P. (1998) Molecular Plant Development: from gene to plant. The Bath Press, UK. ISBN: 9780198502043.
3. Wolpert, L., Tickle, C., Martinez, A. (2015) Principles of Development. Oxford Publishers, UK. ISBN: 9780198709886.
4. Buchanan, B. B., Gruissem, W., Jones, R. L. (2015) Biochemistry & Molecular Biology of Plants. John Wiley & Sons, Ltd, UK. ISBN: 9780470714218.
5. Taiz, L. and Zeiger, E., Moller, I. M. and Murphy, A. (2015) Plant Physiology and Development. Sinauer Associates Inc. Publishers, USA. ISBN: 9781605352558.

<u>**Semester 2**</u>

PBSC202: Plant Biochemistry and Metabolism

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC202: Plant Biochemistry and Metabolism	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

Plant biochemistry and metabolism is the study of biomolecules, biochemical processes, and the pathways of chemical energy flow. This course is designed to impart critical knowledge on plant-specific primary metabolism from a more mechanistic perspective, including photosynthesis, respiration, and metabolism of carbohydrates, lipids, amino acids and nucleotides. The course will also provide information on the uptake, transport and assimilation of nutrients as well as long-distance transport mechanisms in plants. Furthermore, students will also learn to appreciate the importance of secondary metabolites produced by plants.

Learning Outcomes

This paper will lead to a comprehensive understanding of the different metabolic processes operating in a plant system. It would provide insights into the structural diversity of various biomolecules, their movement, synthesis and turnover. It would also help in developing an understanding of the key components in metabolic pathways, with emphasis on the genetic improvement of quality traits.

Course Content (45 hours)

Unit 1: Carbon Assimilation in Photosynthesis, and Uptake and Assimilation of Nutrients - - Light absorption and energy conversion; Calvin Cycle (C_3), Hatch-Slack pathway (C_4), Crassulacean Acid Metabolism (CAM), Reductive pentose phosphate pathway, Carbon dioxide uptake and assimilation, photorespiration, glycolate metabolism; Enhancing photosynthetic carbon assimilation by genetic engineering; Overview of essential mineral elements, molecular physiology of nutrient acquisition (Nitrogen, Potassium, Sulphur, and Phosphorus), role of essential mineral elements in plants; Nitrate uptake, assimilation and transport, nitrate reduction, pathways of ammonia assimilation, reductive amination, trans-amination; Regulation of transport and assimilation of essential nutrients. 17 Hours

Unit 2: Biological Oxidation and Release of Energy -- Glycolytic pathway, Kreb's cycle, high energy compounds; Oxidative phosphorylation; Chemiosmotic hypothesis; Pentose phosphate shunt pathway; Regulation of citric acid cycle and cytochrome pathway; Interactions between mitochondria and other cellular compartments. 10 Hours

Unit 3: Metabolism of Biomolecules and Secondary Metabolites -- Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, and nucleic acids), biosynthesis, inter-conversion and breakdown of carbohydrates and lipids, metabolism of nucleotides and amino acids; Biosynthesis of phenolic compounds, isoprenoids, alkaloids, glucosinolates and flavonoids, phenylpropanoid pathway, mevalonate (MVA) pathway, methylerythritol phosphate pathway; Importance of secondary metabolites; Metabolic engineering of secondary metabolite production; Biotechnological applications of secondary metabolites. 12 Hours

Unit 4: Long-distance Transport Mechanisms in Plants -- Transport of water: long-distance transport and short-distance transport events between xylem and nonvascular cells, transport modules, specific water channels, turgor and stomatal movements, translocation of ions and solutes from soil; Ion transport and solute movement; Passive and Active transport, Short-distance transport between phloem and nonvascular cells; Source-sink relationship, mechanisms of loading and unloading of photoassimilates. 6 hours

Practicals (30 hours)

1. Substrate inducibility of nitrate reductase (NR) enzyme.
2. Determination of optimal pH for nitrate reductase activity.
3. Spectrophotometric assay of acid phosphatase.
4. Isolation of chloroplastic proteins and resolve them using SDS-PAGE.
5. Activity of mitochondrial marker enzyme, succinate dehydrogenase.

Suggested Readings:

1. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry & Molecular Biology of Plants. American Society of Plant Physiologists, USA. ISBN: 9780470714225.
2. Dey, P.M. and Harborne, J.B. (1997) Plant Biochemistry. Academic Press, USA.
3. Metzler, D. E. (2007) Biochemistry. Academic Press, USA. ISBN: 9780122146749.
4. Nelson D. L. and Cox, M. M. (2017) Principles of Biochemistry. W H Freeman & Co., USA. ISBN: 9781319108243.
5. Stryer L., Berg, J. M. and Tymoczko, J.L. (2002) Biochemistry. W.H. Freeman & Co., USA. ISBN: 9780716746843.
6. Ashihara, H., Crozier, A., Komamine, A. (2011). Plant Metabolism and Biotechnology, Wiley. ISBN: 9780470747032.
7. Piechulla, B., Hans-Walter, H. 6th Edition (2024). Plant Biochemistry, Elsevier, Academic Press. ISBN: 9780443266164.

Semester 2

PBSC203: Eukaryotic Gene Expression and Regulation

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC203: Eukaryotic Gene Expression and Regulation	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

This course provides a detailed understanding of eukaryotic genome structure, regulation, and function. It emphasizes advancements in genome sequencing, epigenetics, and functional genomics, including CRISPR-Cas technologies, while exploring their applications in agriculture and human health. Students will develop theoretical knowledge and practical skills to analyze and manipulate genomic systems.

Learning Outcomes

Upon successful completion of this course, students will gain a comprehensive understanding of genome organization, gene regulation, and functional genomics. It will equip them with the ability to interpret high-throughput genomic data and understand regulatory mechanisms at multiple levels. Students will be able to apply this knowledge to genome editing, crop improvement, and medical research. They will also be able to propose innovative solutions to agricultural and health-related challenges by leveraging insights from transcriptional regulation, epigenetics, and emerging genomic technologies.

Course Content (45 hours)

Unit 1: Genomes and Comparative Genomics -- Genome structure and organization; Structure of chromatin and chromosomes; Genome complexity; Nuclear territories; Chromosomal Conformation studies (Hi-C); Unique and repetitive DNA; Evolution of gene families; Advances in genome sequencing technologies (Next-gen and 3rd-gen methodologies, Illumina, PacBio, Nanopore, etc.) and assembly; Optical Genome mapping; Comparative genomics of model organisms (Arabidopsis, rice, humans, and non-model species); Functional annotation through phylogenetic footprinting and multi-genome alignment; Impact of repetitive and transposable elements on genome evolution. 15 hours

Unit 2: Epigenetic and Transcriptional Regulation of Gene Expression -- Mechanisms of DNA methylation and histone modifications; Role of non-coding RNAs and chromatin remodeling in transcriptional regulation; Environmental and developmental epigenetic reprogramming; Case studies: Epigenetic regulation in flowering and stress responses. Promoter and enhancer dynamics; Mechanisms of RNA polymerase recruitment and mediator complex functions; Latest insights into transcription factors, co-activators, and repressors; Chromatin looping and transcription factories. 10 hours

Unit 3: Post-transcriptional Translational and Post-translational Regulation – RNA splicing mechanisms and alternative splicing. RNA editing, stability, transport, and degradation pathways. Regulatory roles of microRNAs, siRNAs, and lncRNAs. Insights into translational regulation and protein synthesis. Global proteomics and functional characterization of protein complexes. Role of post-translational modifications (e.g. phosphorylation, ubiquitination, etc.) and degradation in cellular processes. 10 hours

Unit 4: Functional Genomics and Genome Editing and their Applications-- High-throughput RNA sequencing (single-cell transcriptomics); Spatial Transcriptomics. CRISPR-Cas technologies: principles and applications; Gene Function validation through knockouts, knockdowns, TILLING, and transposon-tagging. Engineering crops with enhanced traits (e.g., drought resistance, pest tolerance); Case studies in transcriptional regulation and its relevance to diseases (e.g., cancer, diabetes). 10 hours

Practicals (30 hours)

1. Plant DNA extraction and quality assessment.
2. Plant RNA isolation and quality assessment.
3. RT-PCR for gene expression analysis.
4. Reporter gene assay for promoter activity (GUS assay, visualization of GFP).
5. CRISPR-Cas9 gene editing (experimental and guide RNA design).

Suggested Readings:

1. Berg, J. M, Tymoczko, J. L., Stryer, L. (2012) Biochemistry. WH Freeman and Company, New York. ISBN-13: 978-1429229364.
2. Buchanan, B. B., Gruissem, W. and Jones, R. (2015) Biochemistry & Molecular Biology of Plants. John Wiley & Sons, Ltd., West Sussex. ISBN-13: 978-0470714218
3. Kahl, G. and Meksem, K. (2008) The Handbook of Plant Functional Genomics. Wiley-VCH Verlag GmbH & Co., Germany. ISBN-13: 978-3527318848
4. Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. (2014) Lewin's Genes XI. Jones and Bartlett Publishers, LLC, Burlington. ISBN-13: 978-1449659851
5. Latchman, D. S. (2015) Gene Control. Garland Science, New York.
6. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin, K. C. (2016) Molecular Cell Biology. WH Freeman and Company, New York. ISBN-13: 978-1464183393
7. Stewart Jr., C. N, (2016) Plant Biotechnology and Genetics: Principles, Techniques and Applications. John Wiley & Sons, Inc., New Jersey. ISBN-13: 978-1118820124

Semester 2

PBSE204: Cell Signaling and Communication

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSE204: Cell Signaling and Communication	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

This course aims to provide a comprehensive understanding of cellular signaling and communication in different organisms. It will cover fundamental signaling pathways, receptor mechanisms, primary and second messengers, and their roles in cellular responses. Students will explore the molecular basis of cell cycle regulation and hormone signaling, with a special focus on plant hormones and their roles in stress responses, growth, and development. The course integrates key regulatory mechanisms, emphasizing experimental insights and biological relevance.

Learning Outcomes

The candidate would learn about cellular signaling and communication, controlling a myriad of cellular processes, and coupling the cellular process with external and internal signals/stimuli. The candidate will develop an essential understanding of how cells communicate with each other and respond to external stimuli, essentially governing all cellular functions like growth, development, and even cell death, making it fundamental to comprehending complex biological processes.

Course Content (45 hours)

Unit 1: Basic Understanding of Cellular Signaling and Communication -- External and internal signals; Different signaling pathways; Analogy of signaling pathways to electronic circuitry; Stimulus response-coupling; Cellular communication through receptors and plasmodesmata; Two-component system; G-protein coupled receptors, receptor tyrosine kinase, receptor-like kinase, ion channel receptor, other cell surface receptors, intracellular hormone receptors, intracellular ligand-receptor. 10 hours

Unit 2: Primary and Second Messengers -- Growth factors and hormones in animals (EGF, interleukins, cytokines, insulin, etc.); Plant hormones (auxins, cytokinins, gibberellins, abscisic acid, etc.); Second messengers (Ca^{2+}, ROS, IP_3, cAMP, cGMP, DAG, etc.). 5 hours

Unit 3: Signaling Pathway in Prokaryotes, Animals, and Plants -- Histidine kinase-based signaling, GPCR-based signaling, receptor tyrosine kinase-based signaling, receptor kinase-based signaling, MAP-kinase-based signaling, Ca^{2+} signaling, phospholipid-based signaling, cyclic nucleotide (cAMP/cGMP)-based signaling; Role of protein kinases and phosphatases in signaling pathways. 12 hours

Unit 4: Plant Hormones Signaling and Regulation of Cell Cycle -- Signal perception of auxin, ABA, GA, cytokinins, ethylene, brassinosteroids, jasmonic acid, salicylic acid, strigolactones, etc.; Regulation of gene expression during signal transduction; Role of mutants in understanding hormone action; Regulation of biotic and abiotic stresses by phytohormones. Overview of cell cycle, progression to mitosis and meiosis; Cell cycle checkpoints, role of cyclin and cyclin-dependent kinases. 18 hours

Practicals (30 hours)

1. Effect of stress signals on growth kinetics of E. coli.
2. Analysis of a calcium sensor and its effector kinase by yeast two-hybrid growth assay.
3. Effect of stress stimuli on plant signaling mutants by analyzing the growth phenotype.
4. Localization of cellular auxin biosensor, DR5::GFP in the roots of Arabidopsis.
5. Effect of abiotic stress signals on key signaling gene expression in Arabidopsis thaliana.

Suggested Readings:

1. Gomparts B.D., Kramer I.M., Tatham P.E.R. (2009) Signal Transduction, Academic Press, USA. ISBN: 9780080919058.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2015) Molecular Biology of the Cell. Garland Publishing, Taylor & Francis Group, USA. ISBN: 9780815344322.
3. Buchanan BB, Gruissem W, Jones RL (2015) Biochemistry and molecular biology of the plants American Society of Plant Physiologists, USA. ISBN: 9780470714218.
4. Karp, J. G., Iwasa, J., Marshall, W. (2019). Cell and Molecular Biology. John Wiley & Sons, USA. ISBN: 9781119598169.
5. Kleinsmith, L. J. and Kish, V. M. (1997) Principles of Cell & Molecular Biology. Harper Collins College Publishers, USA. ISBN: 9780065004045.
6. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretsher, A., Ploegh, H., Amon, A., Martin, K. (2016) Molecular Cell Biology. Freeman & Co., USA. ISBN: 9781464183393.

<u>**Semester 2**</u>

PBSE205: Plant-Environment Interactions

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSE205: Plant-Environment Interactions	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

Adverse environmental conditions significantly impact plant survival and productivity. The paper aims to provide an in-depth understanding of how plants perceive and interact with their environments. Students will learn about the effect of different stresses on plant growth and development, the impact of climate change on plant-environment interactions, and how plants adapt to these changing conditions. The course will introduce experimental approaches, modern techniques, and analytical tools for studying plant stress biology.

Learning Outcomes

Students will be able to understand the interactions between plants and their environment and understand their significance in agriculture and ecology. They will be able to evaluate the changes that plants undergo under challenging conditions and differentiate between the responses to biotic and abiotic stresses. Students will design and execute experiments using physiological, biochemical, and molecular techniques to study plant responses and adaptations. Students will be able to propose innovative solutions for mitigating the adverse effects of environmental stresses on crop productivity using advanced molecular biology and bioengineering approaches. Based on their knowledge they can develop strategies for developing stress-tolerant plants and their applications in sustainable agriculture and environmental remediation.

Course Content (45 hours)

Unit 1: Plant-Environment Interactions and Plant Stress Responses - Overview of abiotic and biotic factors and plant responses; adaptation strategies in different ecosystems (desert, halophytes, aquatic plants, etc.); Role of plant microbiomes in environmental interactions; Stress perception; Stress signal transduction pathways; Role of phytohormones; Epigenetic modifications and non-coding RNAs in plant stress adaptation; Crosstalk between different signaling pathways; Concept of phenotypic plasticity and stress memory in plants 8 hours

Unit 2: **Abiotic Stress Responses** -- Types of abiotic stress factors; Climate change and pollution; Physiological, morphological, biochemical, and molecular changes in plants against different abiotic stresses; Stress tolerance in crops through allelic variation; Genomic and transcriptomic approaches in abiotic stress research; Engineering plants for abiotic stress resilience; Phytoremediation and environmental biotechnology. 12 hours

Unit 3: **Biotic Stress Responses and Symbiotic Interactions** -- Types of biotic stresses; Molecular basis of plant-pathogen interactions (compatible vs. incompatible); Plant defense mechanisms against biotic agents (PTI and ETI); Plant disease resistance and susceptibility genes; Role of Systemic Acquired Resistance (SAR), Induced Systemic Resistance (ISR), and Hypersensitive Response (HR); Role of secondary metabolites; Plant immunity and priming; Effect of climate change on biotic interactions; Genetic and molecular basis of plant-insect interaction; Diversity in parasitic plants; Molecular mechanisms of host-parasite interactions, host plant pre- and post-attachment defense responses; Role of mobile RNAs and proteins in parasitism and defense responses; Rhizobial symbiosis and molecular regulation of nodule development; Interactions with arbuscular mycorrhizal fungi (AMF); Other mutualistic associations; Genomic insights into symbiotic relationships. 18 hours

Unit 4: Experimental Approaches and Applications -- Techniques to study plant stress physiology; Utility of model plant systems (*Arabidopsis*-*Pseudomonas* interaction, Rice-*Magnaporthe* interaction, etc.); Advanced techniques in high-throughput phenotyping, multi-omics approaches, advanced imaging techniques; Use of bioinformatics and AI in predicting plant stress responses; Case studies for development of climate-smart crops; Applications of synthetic biology, breeding, and transgenic technology for sustainable agriculture. 7 hours

Practicals (30 hours)

1. Effect of heat stress on seed germination of Arabidopsis.
2. Determination of membrane stability index (MSI) of plant tissues exposed to drought stress.
3. Detection of reactive oxygen species (ROS) in salt-stressed rice plants.
4. Detection of plant pathogen and disease diagnosis by loop-mediated isothermal amplification (LAMP).
5. Detection of hypersensitive response (HR) during R-Avr interaction in *Nicotiana benthamiana* leaves.

Suggested Readings:

1. Tuteja, N. and Gill, S.S. (2013) Climate Change and Plant Abiotic Stress Tolerance.; Wiley-VCH Verlag GmbH & Co. KgaA. eISBN: 9783527675265.
2. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015) Biochemistry and Molecular Biology of Plants (2nd Edition). Wiley, USA. ISBN: 9781118502198.
3. Dickinson, M. (2003) Molecular Plant Pathology.; BIOS Scientific Publishers - Taylor & Francis Group. ISBN: 9781859960448.

4. Wolpert, T., Shiraishi, T., Collmer, A., Akimitsu, K. and Glazebrook, J. (2017) Genome-enabled analysis of plant-pathogen interactions. ISBN: 9780890544983.
5. Hirt, H. (2009) Plant Stress Biology: From Genomics to Systems Biology. 1st edition. Blackwell Publishers. ISBN: 978352732290.
6. Hull, R. (2014) Plant Virology. 5th Edition, Academic Press, USA. ISBN: 9780123848710.
7. Jenks, M.A. and Hasegawa, P.M. (2014) Plant Abiotic Stress. 2nd Edition, Wiley-Blackwell. ISBN: 9781118412176.
8. Aftab, T. (2023) New Frontiers in Plant-Environment Interactions: Innovative Technologies and Developments (Environmental Science and Engineering). Springer International Publishing AG. 1st edition. ISBN: 978-3031437281.
9. Huang, B. (2006) Plant-Environment Interactions. 3rd edition. CRC Press. ISBN: 978084933727. https://plantstress.com/

Semester 2

PBSE206: Proteomics, Metabolomics and Elementomics

This course is open to students of other departments as a GE course

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSE206: Proteomics, Metabolomics and Elementomics	4	3	1	0	B.Sc. in any branch of Science	NA

Learning Objectives

Protein, metabolite, and ionic/element profiles in living systems are important to understand the regulatory and metabolic capacity of the system. The primary objective of this course is to equip students with the principles of proteome, metabolome, and elementome. The course aims to develop knowledge in the application of state-of-the-art technologies designed to understand the proteome, metabolome and elementome of different organisms, protein modification, and the complexities of protein-protein interactions and metabolic outcomes. There will be a strong emphasis on how these technologies are applied to the agriculture and health sectors.

Learning Outcomes

Students would develop a detailed understanding of the state-of-the-art techniques and analysis methods for the study of the plant proteome, metabolome, and elementome. They will be able to carry out basic experimental design for a given biological condition and compare methods to study proteomics, metabolomics, and elementomics. They will learn to carry out data analysis and skills to interpret data, such as identification of peptides/proteins/metabolites and comparison of proteomes, elementomes, and metabolomes between different groups of samples.

Course Content (45 hours)

Unit 1: Introduction to Proteomics, Metabolomics, and Elementomics -- Introduction to 'Omics'; Protein structure folding and function; Types of Proteomics: structural, functional and expression; Basics and workflow design of proteomics technology; Comparative proteomics; Metabolites and their importance; Elements and their significance; Technological advancements in multi-omics studies; Importance in agriculture and health sciences. 6 hours

Unit 2: Tools and Techniques in Proteomics -- Principles and applications of the separation technology; 1-D and 2-D Polyacrylamide Gel Electrophoresis (PAGE), workflow, high-throughput methods, importance and applications in proteomics; Proteomic Profiling: protein sequencing, Liquid Chromatography and Mass Spectrometry (LC-MS/MS), quantitative proteomics, advanced methods in proteomics; Isotope Coded Affinity Tag based Protein Profiling (ICAT), Isobaric Tags for Relative and Absolute Quantitation: iTRAQ, AQUA, ESI-Q-IT-MS; SELDI-TOF-MS, SWATH), database search, protein identification, and pathway analysis; Post-translational modifications and their profiling; High-throughput methods for detection of protein-protein interactions and interactions of proteins with other biomolecules; Immunoproteomics: Overview of immune systems; Utility of antibodies in routine laboratory experiments; Serological proteome analysis; Protein microarrays (analytical and functional), protein array detection methods; Antigen identification by antigen capture and mass spectrometry; Characterization of the cell-mediated immune response by cytokine detection and quantification; Immuno-PCR; Immunoproteomics for major histocompatibility complex (MHC) peptides 18 hours

Unit 3: Metabolomics -- Types of metabolites; Definition and scope of metabolomics; Sample preparation and extraction techniques; Separation and detection methods: gas chromatography (GC), high-performance liquid chromatography (HPLC), mass spectrometry (MS) secondary ion MS (SIMS), desorption electrospray ionization (DESI), laser ablation electrospray ionization (LAESI), Nuclear Magnetic Resonance (NMR); Statistical tools for data analysis. 11 hours

Unit 4: Elementomics -- Relevance of mineral nutrients and trace elements; Atomic absorption spectroscopy; High-throughput elemental profiling using inductively coupled plasma-mass spectroscopy (ICP-MS), inductively coupled plasma-optical emission spectroscopy (ICP-OES), Energy Dispersive X-ray Spectroscopy (EDS), X-Ray fluorescence spectroscopy, atomic neutron activation analysis; Elemental data analysis. 10 hours

Suggested Readings:

1. Antonio, C. (2018). Plant Metabolomics: Methods and Protocols (Methods in Molecular Biology). Humana Press, USA. ISBN: 9781493992942.
2. Branden, C. I. and Tooze, T. (1999) Introduction to Protein Structure. Garland Publishing, USA. ISBN: 9780815323051.
3. Saito, K., Dixon, R. A. and Willmitzer, L. (2006) Plant Metabolomics (Biotechnology in Agriculture and Forestry). Springer, USA. ISBN: 9783540297819.
4. Lesk, A. M. (2010) Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press, UK. ISBN-0199541302.
5. Lammerhofer, M. and Weckwerth, W. (2013). Metabolomics in Practice: Successful Strategies to Generate and Analyze Metabolic Data. Oxford University Press, UK. ISBN: 9783527330898.
6. Weckwerth, W. (2007) Metabolomics: Methods and Protocols (Methods in Molecular Biology). Humana Press, USA.[1] ISBN: 9781588295613.
7. Fulton, K. M., Baltat, I., and Twine, S. M. (2019). Immunoproteomics methods and techniques. Immunoproteomics: methods and protocols. ISBN: 9781493995967.

Semester 2

PBSD207: Plant Tissue Culture and Transformation Methodologies

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSD207: Plant Tissue Culture and Transformation Methodologies	2	0	0	2	B.Sc. in any branch of Science	NA

Learning Objectives

This course aims to provide hands-on training in plant biotechnology techniques, including plant tissue culture, haploid production, protoplast isolation, plant genetic transformation, and virus-induced gene silencing. Students will gain practical experience in media preparation, sterile techniques, regeneration protocols, and molecular screening for plant improvement and research applications.

Learning Outcomes

Upon completion of this course, students will develop proficiency in key plant biotechnology methods, enabling them to perform plant tissue culture, genetic transformation, and molecular validation independently. They will acquire skills in protoplast manipulation, haploid generation, plant transformation and gene silencing, preparing them for careers in plant tissue culture, crop improvement, and biotechnological innovations.

Hands-on Training (60 hours)

Unit 1: Plant Tissue Culture, Micropropagation, and Protoplast Isolation -- Media preparation, surface sterilization of leaf discs of tobacco/hypocotyls of tomato), callus induction and proliferation, shoot and root regeneration, establishment of plantlets; Haploid Production through Androgenesis: Selection of specific stages of anthers of tobacco/*Datura*, surface sterilization, axenic culture, haploid plant generation; Plant protoplast isolation and transfection: protoplast isolation from leaves/roots of wheat seedlings, viability check using dyes, transformation using PEG method, visualization under confocal microscope. 30 hours

Unit 2: Plant Genetic Transformation and Virus-induced Gene Silencing (VIGS) -- *Agrobacterium tumefaciens*-mediated transformation of Arabidopsis plants using floral dip method, transformants screening, transgene insertion validation by PCR; Agroinfiltration of TRV-*pds* constructs in tobacco leaves, phenotyping, and screening of VIGS lines. 30 hours

Suggested Readings:

1. Gilbert, S. F. (2000) Developmental Biology. INC Publishers, USA. ISBN: 9780197699782.
2. Westhoff, P. (1998) Molecular plant development: from gene to plant. The Bath Press, UK. ISBN: 9780198502043.
3. Wolpert, L., Tickle, C., Martinez, A. (2015) Principles of Development. Oxford Publishers, UK. ISBN: 9780198709886.
4. Bhojwani, S.S. and Razdan, M.K., 1986. Plant tissue culture: theory and practice. Elsevier.
5. Boisson-Dernier, A., Chabaud, M., Garcia, F., Bécard, G., Rosenberg, C., and Barker, D. G. (2001). *Agrobacterium rhizogenes*-transformed roots of *Medicago truncatula* for the study of nitrogen-fixing and endomycorrhizal symbiotic associations. Molecular Plant-Microbe Interactions 14(6), 695–700. DOI: 10.1094/MPMI.2001.14.6.695.
6. Rössner, C., Lotz, D., and Becker, A. (2022). VIGS goes viral: How VIGS transforms our understanding of plant science. *Annual Review of Plant Biology*, 73, 703–728. DOI: 10.1146/annurev-arplant-102820-020542.

Annexure-5

UNIVERSITY OF DELHI
MASTER OF SCIENCE (ELECTRONICS)
based on
NEP-PGCF-2024

As approved in the meeting of 'Committee of Courses' held on 11th March 2025, in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on ____17th March, 2025_________, and meeting of 'Standing Committee' held on _____________

PROGRAMME BROCHURE

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2025 and Executive Council on YYYY, 2025

I. About the Department

Background of Department

The Department of Electronic Science was established in 1985 and is widely recognised as one of the most prestigious Electronic Science Departments in the country.

The Department is conducting courses leading to M.Tech. in Microwave Electronics and M.Sc. in Electronics. The aim of these programmes is to provide the necessary theoretical background and practical experience in order to meet the requirements of the R&D Organizations and Industries. In addition, the M.Tech. students work for 6 months on projects in collaboration with Industry and R&D Organisations and the M.Sc. students do in-house six months projects in the final semester. The curriculum of these courses is updated regularly to keep it in consonance with the changing industrial environment. Workshops/ seminars and hands-on workshops are organized on a regular basis to bridge the gap between academia and industry, and to provide requisite exposure to the students about the latest technological developments taking place in varied areas related to microelectronics, microwaves, communication, photonics etc. The interface with industry is further enhanced by an annual seminar under the Visitors' Programme in which professionals from industry, R&D organizations and academics are invited. Our alumni, now spread over a large number of government and private organisations, facilitate these interactions.

A full range of resources and facilities are available to the students. The Department has a well-equipped computer laboratory with various circuit simulation and microwave design software for students. In addition, there are well equipped laboratories for experimental work in the following areas: Microwave Measurements, Communication Electronics, Circuit Design, Electronic Materials and Semiconductor Devices, Microprocessors and Digital Signal Processing, Optical Electronics, Anechoic chamber and Microwave Component Fabrication. An assessment of students' performance is made through continuous series of tests and presentations in addition to semester end examinations to ensure highest standards.

The Department is actively helping the students in their placement through Campus interviews. Students graduating from the Department have found positions in both government and private organizations working in the areas of Semiconductors, Information Technology, Telecommunications, Defence and Space Applications, etc. The students graduating from the programs have the necessary theoretical and practical skills to take on any R&D and Production responsibilities in today's complex and challenging environment. This is evident from the contributions and achievements of our alumni in organizations like ST Microelectronics, Cadence, HFCL, Aricent, Transwitch, SAMEER, ISRO, Keysight Technologies, VVDN Technologies, DRDO laboratories like DEAL, LRDE and many more.

Department Highlights

The Department is well established with thirteen faculty members. Extramural grants from DST, CSIR, DRDO, ISRO, etc as well as intramural grants from the University of Delhi, have strengthened the Department's research. The Department was also funded under the DST-FIST, UGC 12th plan and DU-DST PURSE programs. The Department has well-equipped teaching and research laboratories with state-of-the-art equipment for fabrication, characterization and measurement in the areas of microwave measurement, electronic materials and semiconductor devices, communication electronics, photonics etc. A large number of TCAD and EDA tools are also available that further enhances and strengthens teaching and research. The students graduating from these programmes acquire the necessary theoretical and practical skills to take up roles in R&D organizations, academia as well as industry. Since the inception of these programmes, the Department has witnessed several success stories and our students have done exceptionally well and are placed in some of the most reputed government as well as private organizations such as SSPL, NPL, DEAL, IRDE, BEL, SAMEER, ISRO, Keysight technologies, VVDN Technologies, ST Microelectronics, cadence, NXP ARM, etc.

About the Program

The M.Sc. Electronics program offered by University of Delhi is of two years' duration and is divided into four semesters. The various courses of the program are designed to include classroom teaching and lectures, laboratory work, project work, viva, seminars, and assignments. Six categories of courses are being offered in this program: Department Specific Core (DSC) Courses, Department Specific Elective (DSE) Courses, Generic Elective (GE) courses (student may opt for any of the Generic Elective courses offered by any other Department of the Faculty of Interdisciplinary and Applied Sciences), Skill Enhancement Courses (SEC), Research methods/ techniques of research writing, and Dissertation/Problem based Research work. The Core Courses and Discipline Specific Elective Courses are four-credit courses. The Generic Electives are also four-credit courses. The student is required to accumulate twenty-two credits each semester i.e. a total of eighty-eight credits over four semesters to fulfil the requirements for a Master of Science degree in Electronics (two-year program), and forty-four credits over two semesters to fulfil the requirements for a Master of Science degree in Electronics (one-year program).

About Post-Graduate Attributes

The curriculum is designed to train the students in basic and advanced areas of Electronics, keeping in mind the latest advances in the field. Particular emphasis is laid on the practical aspects of the field. Students are taught how to plan experiments, perform them carefully, analyze the data accurately, and present qualitative and quantitative results. To enable them to develop speaking and presentation skills they are encouraged to deliver seminars on a wide range of topics covering the different areas of Electronics. This enhances their assimilation abilities. A major component of their course in Structure 2 and Structure 3 is a research project they undertake in their final year. The student is guided in choosing a research problem, executing experiments related to it, collecting data and analyzing it, and presenting the results in the form of an oral presentation as well as a thesis. The student presents their research orally at the end of the final semester of the program, coupled with a viva-voce exam. This not only equips the student for a career in research/ industry, but also fosters self-confidence and self-reliance in the student as they learn to work and think independently. At the end of the program the student will be well-versed in essential electronics as well as the most recent advances in varied specialized areas. Thus, the program will prepare students for various opportunities in academia or industry, and equip them to pursue a career in research if so desired.

Program Objectives (POs):

At the time of completion of the program the student will have developed extensive knowledge in varied areas of Electronics. Through the stimulus of scholarly progression and intellectual development, the program aims to equip students with excellence in education and skills, thus enabling them to pursue a career of their choice. By cultivating talents and promoting all-round personality development through multidimensional education, a spirit of self-confidence and self-reliance will be infused in the student. The student will be instilled with values of professional ethics and be made ready to contribute to society as responsible individuals.

Program Specific Outcomes (PSOs):

At the end of the two-year program, the student will gain requisite exposure in different branches of Electronics such as Microelectronics, RF & Microwaves, Communication and Photonics, Digital Signal Processing, Terahertz Technology etc. They will be able to design and execute experiments related to advanced Analog and Digital Circuits, Signal Processing, Embedded Systems, RF& Microwave Systems, and Optical Communication. They will also be able to execute a research projects in varied areas under supervision. The student will be equipped to take up a suitable position in academia or industry, and pursue a career in research if desired.

About Program Structure

The M.Sc. Electronics program is a two-year program divided into four semesters, or a one-year program divided into two semesters. A student has to accumulate twenty-two credits in each semester. Under the two-year M.Sc. program a student is required to complete eighty-eight credits for completion and award of M.Sc. degree, while under the one-year M.Sc. program a student is required to complete forty-four credits for completion and award of M.Sc. degree. The program structure is based on the Post Graduate Curricular Framework (PGCF) under New Education Policy (NEP)-2020. Under PGCF, in the first year of the two-year program, the student is required to study mandatory Discipline Specific Core courses (three DSC in each semester) and a total of four / Discipline Specific Elective courses (two DSE in each Semester). In lieu of one DSE in each Semester, the student may choose to study a Generic Elective course offered by any other Department of FIAS. In addition, the student will also be required to study one mandatory Skill enhancement course (SEC) in each semester of the first year. In the second year of the two-year program, the student will have an option to choose any one of the three structures: Structure 1 (PG with only coursework), Structure 2 (PG with coursework and research), or Structure 3 (PG with coursework and more emphasis/weightage on research). The details regarding these structures have been summarized in tabular form.

Course Credit Scheme

Structure-1: (PG with only coursework)

Sem	*Core courses*		*Elective courses*		*Skill based courses*		*Res Method courses*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	3	12	1	2	-	-	-	-	22
IV	2	8	3	12	1	2	-	-	-	-	22
Total Credits	**40**		**40**		**8**		**-**		**-**		**88**

Structure-2: (PG with coursework and research)

Sem	*Core courses*		*Elective courses*		*Skill based courses*		*Res Method courses*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	2	8	-	-	-	-	1	6	22
IV	2	8	2	8	-	-	-	-	1	6	22
Total Credits	**40**		**32**		**4**		**-**		**12**		**88**

Structure-3: (PG with research)

Sem	*Core courses*		*Elective courses*		*Skill based courses*		*Res Method courses*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	1	4	1	4	-	-	2	4	1	10	22
IV	-	-	1	4	-	-	1	2	1	16	22
Total Credits	**26**		**24**		**4**		**6**		**26**		**88**

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. ELECTRONICS COURSE (NEP-PGCF)

First year (common in Structure 1, 2 and 3)

Semester-1

	Credits in each course			
	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-01: Network Theory and Filter Design	3	1	0	4
DSC-02: CMOS Analog Circuit Design	3	1	0	4
DSC-03: Digital Circuit Design	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-01: Mathematical Techniques and Applications	3	1	0	4
DSE-02: Signal Processing and Control	3	1	0	4
DSE-03: Soft Computing Techniques	3	1	0	4
DSE-04: Advanced Sensors and Transducers	3	1	0	4
Generic Elective courses*				
GE-01: Modern Engineering Applications of RF and Microwave Spectrum	3	0	1	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
SEC-01: Fabrication & Testing Laboratory	0	2	0	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				

***** *(a student can opt for either two DSE course, or one DSE with one GE)*

Semester-2

	Credits in each course			
Course	Theory	Practical	Tutorial	Credits
Discipline Specific Core (DSC) courses				
DSC-04: Advanced Electronic Materials and Devices	3	1	0	4
DSC-05: Real Time Embedded System Design & IoT	3	1	0	4
DSC-06: Electromagnetics, Antenna and Propagation	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-05: RF and Microwave Components	3	1	0	4
DSE-06: CMOS Digital Integrated Circuit Design	3	1	0	4
DSE-07: Opto-electronics	3	1	0	4
DSE-08: Terahertz Technology and Applications	3	1	0	4
Generic Elective courses*				
GE-02: Introduction to Brain-Computer Interface	3	0	1	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
SEC-02: Embedded-IoT Product Development and Testing	0	2	0	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

***** *(a student can opt for either two DSE course, or one DSE with one GE)*

DISCIPLINE SPECIFIC CORE COURSE – DSC 01

Network Theory and Filter Design

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-01: Network Theory and Filter Design	4	3	-	1	Entry level	Circuit Theory and Network Analysis.

Learning Objectives

The Learning Objectives of this course are as follows:

- To discuss the concepts of graph theory and its role in network analysis.
- To conceptualize the analogous system and apply the network theorems to solve the network with dependent sources.
- To illustrate and outline the Multi-terminal network.
- To understand the synthesis of the Network function.
- To explain the concept of Modern filter theory.

Learning Outcomes

At the end of this course, students will be able

- To explain network problems using the concept of Graph theory.
- To describe the modeling of an analogous system and its solution by applying network tools.
- To determine the response of networks consisting of dependent sources.
- To synthesize the network with the help of Electrical Elements.
- To design the filters with the help of Electrical Elements.

SYLLABUS OF DSC-01 Total Hours: 45h

UNIT -I (12 Lectures)

Network Topology: Definition and properties, Matrices of Graph, Network Equations & Solutions: Node and Mesh transformation; Generalized element; Source transformation; Formulation of network equations; Network with controlled sources; Transform networks; Properties of network matrices;

Solution of equations; Linear time-invariant networks; Evaluation of initial conditions; Frequency and impedance scaling.

UNIT – II (10 Lectures)

Analogues System, Dependent Sources, Applications of Network Theorems for analyzing the Circuit with Dependent Sources, Compensation theorem, Tellegen's theorem. Multi-terminal Networks: Network function, transform networks, natural frequency (OCNF and SCNF); Two-port parameters, Equivalent networks.

UNIT – III (13 Lectures)

Network Synthesis: Network Function (Impedance & Admittance), Stability, Properties of Hurwitz Polynomial and Positive Real Function, Synthesis of LC, RC and RL Network, Foster form, and Cauer form.

UNIT – IV (10 Lectures)

Modern Filter theory, Approximation functions for filters, Maximally Flat Magnitude function, Synthesis of Butterworth and Chebyshev filters, Active filters.

List of Experiments: Total Hours: 30h

A. Software Based [Using PSpice Create netlist.]

1. Write the netlist for the circuit and run PSpice on it for dc analysis. [Independent Source]
2. Write the netlist for the circuit and run PSpice on it for dc analysis. [Dependent Source]
3. Write the source file for the given circuit in using commands [.DC, .PLOT, and .PROBE] to find the I-V characteristic equation for I varying from 0 to -2 A at the given terminal.
4. Use. TRAN and . PROBE to plot the voltage across the parallel RLC combination for R = 50 Ω and 150 Ω for 0 < t < 1.4 ms. The initial conditions are I(0) = 0.5 A and V(0) = 0.
5. Perform an AC analysis on the circuit. Find the complex magnitude of V2 for f varying from 100 Hz to 10 kHz in 10 steps.
6. Step response of the given circuits.

B. Hardware Based.

1. To study Analog Multiplier and Divider Circuits using OP-AMP.
2. To design the Circuit to get the solution of the Differential equation using OP-AMP.
3. To study OPAMP as an Antilog Amplifier (Exponential Amplifier) and Logarithmic Amplifier circuits and study their responses.
4. To study a Frequency Divider Circuit using a Monostable Multi-vibrator.
5. To study a Notch filter using OP-AMP for a given cut-off frequency.
6. Design and determine the characteristics of Active filters: Bandpass, Bandstop.

Essential/recommended readings:

Text Books:

1. V.K. Aatre, Network Theory & Filter Design, New Age International Pvt. Ltd, 2014
2. M.S. Sukhija, T.K. Nagsarkar, Circuits and Networks, Oxford University Press, 2016, 2nd ed.
3. Franklin F. Kuo, Network Analysis and Synthesis, Wiley, 2006, 2nd ed.

Reference Books:

1. M.E. Van Valkenburg, Introduction to Modern Network Synthesis, John Wiley & Sons (1 January 1966)
2. Balabanian, N. and T.A. Bickart, "Electric Network Theory", John Wiley & Sons, New York, 1969.
3. C. L. Wadhwa, Network Analysis and Synthesis, New Age International Pvt. Ltd., 2018

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

DISCIPLINE SPECIFIC CORE COURSE – DSC 02

CMOS Analog Circuit Design

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-02: CMOS Analog Circuit Design	4	3	–	1	Entry level	Basic circuit theory, basic semiconductor physics

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the working and operation of novel and advanced devices
- To develop the ability to design and analyze MOSFET based Analog VLSI circuits
- To draw the equivalent circuits of MOS based Analog circuits and analyze their performance.
- To develop the skills to design analog VLSI circuits for a given specification.

Learning Outcomes

At the end of this course, students will be able

- To draw the equivalent circuits of MOS based analog circuits and analyze their performance.
- To analyze the frequency response of the different configurations of an amplifier.
- To appreciate the design features of the differential amplifiers.
- To use EDA tools and SPICE software for design and analysis of complex analog circuits

SYLLABUS OF DSC -02 Total Hours: 45h

UNIT -I (09 Lectures)

MOS device Physics: MOS I/V characteristics, long channel characteristics, MOS device models, short channel effects, mobility degradation and velocity saturation, channel length modulation, drain induced barrier lowering, subthreshold leakage, gate leakage, tunneling, impact ionization, dielectric breakdown, high-k dielectrics, concept of gate stack.

Advanced Semiconductor devices- Double Gate MOSFET, SOI, FinFETs, strained devices, etc

UNIT – II (12 Lectures)

Single-stage amplifiers: Single stage amplifiers - Impact of second order effects such as channel length modulation, calculation of characteristics such as voltage gain, input and output impedance - Common source (CS) stage with resistive load, substrate bias effect, Common Source stage with diode connected load, current source load, Common Source stage with source degeneration, Source follower, Common gate stage, Cascode stage

UNIT – III (12 Lectures)

Differential amplifiers: Single ended and differential operation, Basic differential pair (qualitative and quantitative analysis), Common-mode response, Differential pair with MOS loads, Gilbert cell.

Current mirrors: Basic current mirrors, Cascode current mirrors

UNIT – IV (12 Lectures)

Frequency response of amplifiers: Miller effect, High frequency response of Common source stage, Source followers, Common gate stage, Differential pair.

Noise: Types of noise, representation of noise in circuits, noise in single stage amplifiers

List of Experiments: Total Hours: 30h

1. Design nMOSFET and pMOSFET devices and draw the I-V characteristics
2. Design a single stage CS amplifier and study the characteristics
3. Design single stage amplifiers with active load and study the characteristics
4. Design a differential amplifier and study the characteristics
5. To study the high frequency response of CS amplifier.
6. To study the high frequency response of CD and CG amplifiers
7. To study the impact of second order effects on performance of amplifiers

Essential/recommended readings:

1. Behzad Razavi, Design of Analog CMOS Integrated Circuits, TMH Edition, 2017, ISBN-10 938706784X, ISBN-13 978-93259832742.
2. R. Jacob Baker, CMOS Mixed-Signal Circuit Design, Wiley Interscience, 2008, ISBN-10 9788126516575, ISBN-13 978-8126516575
3. Kenneth Martin Chan Carusone, David Johns, Analog Integrated Circuit Design, Wiley Student Edition, 2013, ISBN-10 9788126543939, ISBN-13 978-8126543939
4. Muhammad H. Rashid, Microelectronic Circuits - Analysis and Design, Cengage learning, 2011, 2nd Ed, ISBN-13: 978-0-495-66772-8
5. Sedra and Smith, Microelectronic Circuits, Oxford Series, 6th Ed.

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

DISCIPLINE SPECIFIC CORE COURSE – DSC 03 Digital Circuit Design

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-03: Digital Circuit Design	**4**	**3**	**0**	**1**	**Entry level**	**Basic knowledge of binary system and Boolean algebra**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide knowledge of Digital systems are crucial in modern technology because they offer superior accuracy, reliability, flexibility, and ease of data manipulation compared to analog systems.
- To provide the comprehensive knowledge of designing of combinational and sequential circuits and their analysis too.
- To learn the use of computer aided tools and techniques for designing of synchronous & Asynchronous Sequential Circuits.
- To provide the concepts and techniques for Datapath and FSM design.

Learning Outcomes

At the end of this course, students will be able

- To design a combinational and sequential digital circuit design techniques.
- To learn the concepts and techniques for datapath and FSM design.
- To learn concept of fault detection and location in combinational circuits.
- To use computer aided tools and techniques for designing of synchronous & Asynchronous Sequential Circuits.

SYLLABUS OF DSC-03 — Total Hours: 45h

UNIT -I (10 Lectures)

Combinational Circuit Design Principles: The tabulation method (Quin Mc-clusky), Determination of Prime implicants, Selection of Essential Prime implicants, Iterative Consensus method, Map-entered variables method of minimization. Design of Multiplexer.

UNIT – II (10 Lectures)

Synchronous Sequential Circuit Design: Basic memory elements, Analysis of clocked synchronous sequential circuits and modelling, State diagram, state table, state table assignment and ASM chart, Ripple Counters, Synchronous counters.

UNIT – III (12 Lectures)

Asynchronous Sequential Circuit Design: Analysis of asynchronous sequential circuit, flow table, primitive flow table, flow table reduction, races-state assignment, transition table and problems in transition table, design of asynchronous sequential circuit using SR latch. Static, Dynamic and Essential hazards, Elimination of static Hazards, Metastability and Synchronizers for Asynchronous signals, Clock skew, Set up and Hold time of a flip-flop.

UNIT – IV (13 Lectures)

Fault detection and location in combinational circuits:

Introduction to testing and fault diagnosis in digital circuits, Fault modelling, Fault detection and Fault location by path synthesizing method, Fault table method, Boolean difference method.

List of Experiments: **Total Hours: 30h**

1. Design and hardware implementation of 4-bit magnitude comparator.
2. Design and hardware implementation 4:1 Multiplexor using basic gates.
3. Design and Implementation of given Boolean function using multiplexer.
4. Design and hardware implementation of 3:8 Decoder using NAND gates.
5. Design and hardware implementation of Serial Adder.
6. Design and analyse a synchronous sequential circuit.
7. Realization of Mod 8 up-down ripple counter using flip-flops and gates.
8. Design and Hardware Implementation of 4-bit Sequence Detector.
9. Design a sequential circuit for given state diagram using flip-flops.

Essential/recommended readings:

1. S. C. Lee, Digital Circuit and Logic Design, Prentice-Hall, 1976.
2. Kohavi and Jha, Switching and Finite Automata, Cambridge university press, 2010, 3rd edition.
3. M. Morris R. Mano, Michael D. Ciletti, Digital Design, Pearson Education, 2012, 5th edition.
4. Cem Unsalan and bora Tar, Digital System Design with FPGA, Mc Graw Hill Education, 2017.
5. Michael Ciletti Advanced Digital Design with the Verilog HDL, Prentice Hall, 2011, 2nd edition.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 01

Mathematical Techniques 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		
DSE-01: Mathematical Techniques and Applications	**4**	**3**	**–**	**1**	**Entry level**	**Basic mathematics and basic programming skills.**

Learning Objectives

The Learning Objectives of this course are as follows:

- To utilize the mathematical models to understand the device physics and their working.
- To formulate real-world problems into mathematical models.
- To utilize appropriate computational techniques to solve those models, analyze the results, and effectively communicate their findings using mathematical and computational tools.

Learning Outcomes

At the end of this course, students will be able

- To design mathematical models to understand the device physics and their working principle.
- To develop skill and ability to model real-world systems, draw inferences, and apply quantitative reasoning across various disciplines.
- To gain the ability to interpret and draw conclusions from data and mathematical models.
- To break down complex problems into smaller, manageable steps and develop computational solutions.

SYLLABUS OF DSE-01 Total Hours: 45h

UNIT -I (12 Lectures)

Differential Equations: Introduction to First order, second order, homogeneous, non-homogeneous equations, system of equations and their applications to LTI systems.

Orthogonal Functions in Mathematical Physics and Engineering: Bessel Functions, Hermite Polynomials, Chebyshev Polynomials.

UNIT – II (11 Lectures)

Fourier Series & Transform: Definition and Properties, Fourier Series in the Interval, Uses of Fourier Series, Physical Examples of Fourier Series, Fourier sine and cosine transform of Derivatives, Finite Fourier Transform, Applications of Fourier Transform.

UNIT – III (12 Lectures)

Laplace Transform: The Region of Convergence for Laplace Transforms, Inverse Laplace Transform, Properties of the Laplace Transform, Laplace Transform Pairs. Evaluation of differential equations using Inverse Laplace Transform, Applications of Laplace Transform to Integral Equations and ODEs.

UNIT – IV (10 Lectures)

Computational Techniques using MATLAB: Managing the workspace, Matrix and Vectors, Matrix and Array operations, Arithmetic and Logical operations, MATLAB scripts and functions (m-files), Control structures (if, if-else, else-if, switch, for, while etc), Plotting of data: contour plot, surface plot, mesh plot, 3-D plot etc.

List of Experiments: **Total Hours: 30h**

1. Write a program to perform Statistical operation on random data (mean, var, standard Deviation).
2. Write a program to perform Functions and Control Structures (if, if-else, else-if, switch, for, while).
3. Write a program to perform Plotting of Data-Contour Plot, Surface, Mesh Plot, 3-D Plot & polar plot.
4. Write a program to perform/solve Differential Equations..
5. Write a script to Calculates factorial of a non-negative integer (with and without functions).
6. Using MATLAB/Python to plot the Fourier Transform of any Time Function of your choice.
7. Calculate the Laplace transform F(s) of a given function f(t) using MATLAB/Python and verify manually.
8. Program to perform Curve Fitting on any data using standard methods in MATLAB/Python.

Essential/recommended readings:

Text Books:

1. Simon & Haykins, Signals & Systems, Wiley Eastern Ltd.,
2. Zeimer, Signals & Systems, PHI.
3. B. S. Grewal: "Higher Engineering Mathematics", Khanna publishers, 44th Ed. 2018
4. E. Kreyszig: "Advanced Engineering Mathematics", John Wiley & Sons. 2016

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 02

Signal Processing and Control

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		
DSE-02: Signal Processing and Control	4	3	–	1	Entry level	Higher Engineering Mathematics and Signals and Systems.

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the concepts of signal processing and its related terminology.
- To elaborate on the various transformations and their role in science and Engineering.
- To understanding the control Systems and their application.
- To know various Controllers/Compensators and their applications.
- To explore the stability of the system in the Frequency domain.

Learning Outcomes

At the end of this course, students will be able

- To describe the signal processing techniques and their application.
- To represent the signal and analyze the system in the Frequency domain.
- To illustrate the control Systems and their application.
- To design the various controllers/compensators and their application.
- To explain the stability of the system in the Frequency domain.

SYLLABUS OF DSE-02 Total Hours: 45h

UNIT -I (11 Lectures)

Z-transform; Frequency Analysis of Signals and Systems; Discrete Fourier Transform (DFT), FFT, and Window Function; Examples of control systems and applications, Basic components of control systems, Open loop and closed loop control systems.

UNIT – II (10 Lectures)

Digital filters; Digital Filter Design: Butterworth, Elliptic, Chebyshev low-pass filters. Filter Realizations: Convert low pass to high pass, band pass, and band stop filters. Discrete-time filters: IIR and FIR. Linear phase filters.

UNIT – III (10 Lectures)

Concepts of State, State Variables: State equations from transfer function Transfer function from state equations, State transition matrix, Time Response of Control Systems: Transient and steady-state response, typical test signals, Steady state error, and error constant.

UNIT – IV (14 Lectures)

Design of P, PI, PD, and PID controllers. Introduction to compensation design using Bode plot, Nyquist plot, Stability, Root Locus Methods: Root locus concept, Properties, and construction of root locus

List of Experiments: **Total Hours: 30h**

1. Write MATLAB code to compute the linear convolution of two finite-length sequences. Compare your result with that obtained by theoretical evaluation.
2. Write MATLAB code to verify the following general properties of the LTI system.
   a. Linearity
   b. Time-invariance
3. Write MATLAB code to generate the discrete time signal from the analog signal using the sampling theorem and analyze the aliasing effect. Plot the spectrum of the sampled signal—computation of N-point DFT and FFT of the length-N sequence.
4. Write MATLAB code to test the stability of the system.
5. Write MATLAB code to design a digital filter (FIR/IIR) and evaluate its performance.
6. Write MATLAB code to get the system's time response from the state space model.
7. Write MATLAB code to get the system's transfer function represented by the Block diagram.
8. Write MATLAB code to plot the system's root locus, Bode, and polar plot.
9. Write MATLAB code to get the Nyquist plot.
10. Write MATLAB code to show the time response of the Compensated and Uncompensated system.

Essential/recommended readings:

Text Books:

1. Oppenheim, A. S. Willsky and H. Nawab, “Signals and Systems,” , Prentice-Hall, 1996, 2nd Ed.
2. Modern Control Engineering by K. Ogata, Pearson, 2015, 5th edition,
3. Automatic Control Systems by F. Golnaraghi and B.C.Kuo, Wiley Student Edition, 2014, 9th edition.

Reference Books:

1. A. V. Oppenheim, Ronald W. Schafer and John R. Buck, “Discrete-Time Signal Processing,” 2nd Ed., Prentice Hall, 1999.

2. J. G. Proakis, and D. K. Manolakis, "Digital Signal Processing," Prentice Hall, 2006, 4th Ed. 2006.
3. Modern Control System Theory by M. Gopal, New Age International(P) Ltd., 1994, 2nd edition

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 03
Soft Computing Techniques

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		
DSE-03: Soft Computing Techniques	**4**	**3**	**–**	**1**	**Entry level**	**Calculus and Set theory**

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the Conventional AI to Computational Intelligence.
- To demonstrate Machine Learning Techniques.
- To understand the Concept of fuzzy logic and its scope.
- To explain Fuzzy logic techniques for Control, Clustering, and Classification tasks.
- To develop Real-time applications using Machine learning and Fuzzy logic techniques.

Learning Outcomes

At the end of this course, students will be able

- To explain the components of Soft Computing and its role in Engineering.
- To describe the tools of Soft computing.
- To develop a Machine learning algorithm.
- To create a Fuzzy inference system based on fuzzy logic theory.
- To apply genetic algorithms to find optimal solutions.

SYLLABUS OF DSE-03 Total Hours: 45h

UNIT -I (12 Lectures)

Introduction to Soft Computing: Conventional AI to Computational Intelligence, Soft Computing Techniques, Importance of Soft Computing, Main Components of Soft Computing, Hybrid Intelligent Systems, Single and multi-objective optimization. Gradient-based methods: Newton-Raphson method, Bisection method, Secant method, Cauchy's steepest descent and Newton's method.

UNIT – II (10 Lectures)

Artificial Neural Network and Applications: Introduction, Artificial Neuron Structure, ANN Learning; Back-Propagation Learning, Properties of Neural Networks, Unsupervised learnings, Hopfield Networks, Application of GN Models, Statistical Classifier, Linear classifier

UNIT – III (12 Lectures)

Introduction to Fuzzy Logic: Introduction, Uncertainty and Information, Types of Uncertainty, Introduction of Fuzzy Logic, Fuzzy Sets and its properties, Fuzzy Intensification, α-Cuts, Characteristics of Fuzzy Sets, Various
Shapes of Fuzzy Membership Functions, Methods of Defining of Membership Functions, Fuzzy Relation, Defuzzification Methods.

UNIT – IV (11 Lectures)

Introduction to Genetic Algorithm, Crossover, Mutation, Survival of Fittest, Population Size, Evaluation of Fitness Function. Fuzzy inference systems: Introduction, Mamdani fuzzy model, Sugeno fuzzy model, Tekamoto fuzzy model, Neuro-fuzzy systems, applications to fuzzy control, clustering, and classification.

List of Experiments: **Total Hours: 30h**

1. Write MATLAB code to realize the logical AND function with a neural net that learns the desired function through Hebb learning.
2. Linear classification using least squares. Construct an ROC curve for a least squares linear classifier applied to a data set where the two classes overlap significantly. Set the distance between the centers of the two classes at two standard deviations to ensure a fair number of misclassifications.
3. Use the linear SVM to classify a linearly separable data set. Use gen _ data2 to produce a training set (N = 100) with two classes identified as class −1 and class +1, which are Gaussian distributed and separated by 5 standard deviations.
4. Example of k-nearest neighbors classification of Two nonlinearly separable classes. k = 5 and 15.
5. Classify a two-variable input pattern consisting of two classes. Each class consists of 50 patterns having a Gaussian distribution over both variables. The centers of the two classes are far enough apart so that the classes are linearly separable.
6. Single Neuron Training using the Delta algorithm.
7. Train a three-layer net to classify a training set that consists of two classes arranged diagonally across from one another. Use a 100-point training set and a net with six neurons in the input and hidden layers. Evaluate the trained net on a test set of 400 points.
8. Trains a three-layer neural net with and without momentum.
9. FIS Editor and its Application.
10. Understand the Graphical User Interface of Neural Networks.
11. Minimize the given objective function within the specified range using the GA tool.

Essential/recommended readings:

Text Books:

1. Siman Haykin, Neural Networks: A Comprehensive Foundation, IEEE, Press, MacMillan, N.Y. 1994.
2. S. Rajasekaran, G. A. Vijayalakshmi, Neural Networks, Fuzzy logic and Genetic algorithms, PHI publication, 2003.
3. Timothy J. Ross: Fuzzy logic with Engineering Applications - Wiley, 2011.
4. George J. Klir and Bo. Yuan: Fuzzy Sets and Fuzzy logic: Theory and Applications - Pearson, 2015.
5. Kalyanmoy Deb, Optimization for Engineering Design, PHI publication, 2012.
6. Kalyanmoy Deb, Multi-objective Optimization using Evolutionary Algorithms, Willey Publication, 2008.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 04
Advanced Sensors & Transducers

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		
DSE-04: Advanced Sensors & Transducers	**4**	**3**	**–**	**1**	**Entry level**	**Basic electronics**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide an in-depth exploration of various types of transducers and their working mechanism.
- To provide the knowledge of data acquisition systems, and data transfer techniques.
- To understand fundamental principles of sensors and actuators, including their classifications, working mechanisms and characteristics.
- To develop the ability to use different type of sensors like mechanical, electrical, optical, chemical, and pressure sensors in in various fields

Learning Outcomes

At the end of this course, students will be able

- To learn the concept of transducers including the knowledge of various transducers based on industrial requirements.
- To understand about the data acquisition systems, data transfer techniques, and PC-based data acquisition systems.
- To identify the appropriate sensor for a given application.
- To use the knowledge of their construction, operation, signal conditioning, calibration techniques, and limitations across various applications.

SYLLABUS OF DSE-04 Total Hours: 45h

UNIT -I (12 Lectures)

Transducers: Transducers and their need, Primary and Secondary Transducer, Active and Passive Transducer, Unidirectional and Bi-Directional Transducer, Pressure to current Converter (Flapper

Nozzle Arrangement), Diaphragm Pressure Gauge, Piezoelectric transducer, Antenna as a Transducer, LVDT (Linear variable Differential Transformer), Transducers in HVAC (Heat Ventilation and Airconditioning), Interference, Grounding and Shielding

UNIT – II (10 Lectures)

Sensors-I: Capacitive sensors: Variable distance-parallel plate type, variable area- parallel plate, cylindrical type, variable dielectric constant type.
Radiation sensors: LDR, Photovoltaic cells, photodiodes, photo emissive cell types.

UNIT – III (12 Lectures)

Sensors-II: Thermal sensors: Material expansion type: solid, liquid, gas & vapor
Resistance change type: RTD materials, tip sensitive & stem sensitive type, Thermister material, shape, ranges and accuracy specification.
Thermo emf sensor: types, thermoelectric power, general consideration, Junction semiconductor type IC and PTAT type.
Magnetic sensors: Sensor based on Villari effect for assessment of force, torque, proximity, soil sensors.

UNIT – IV (11 Lectures)

Data Acquisition System:
Sample and Hold Circuit, Operational Amplifier, CMRR, Slew Rate, Gain, Band-width. Sample and hold circuits, Zero crossing detector, Peak detector, Window detector. Difference Amplifier, Instrumentation Amplifier AD 620, Interfacing of IA with sensors and transducer, Basic Bridge amplifier and its use with strain gauge and temperature sensors, Filters in instrumentation circuits.
Data Transfer Techniques: Serial data transmission methods and standards RS 232-C, GPIB/IEEE - 488, LAN, Universal serial bus, HART protocol, Foundation -Fieldbus, ModBus, Zigbee and Bluetooth,
Graphical Interface (GUI), PC - Based data acquisition system

List of Experiments: **Total Hours: 30h**

1. Design a VI Interface to study characteristics of inductive transducer LVDT.
2. Design a VI Interface for Monitoring and Controlling of Soil Humidity.
3. Design a VI Interface for Temperature and Pressure Sensors
4. Design a VI Interface to study to study about photodiode and photo transistor.
5. Design a VI Interface using DAQ for Real-Time Data Monitoring PV Solar Cell.
6. Design a VI for recognition of optical character in Speech Synthesis System
7. Design a VI for Fault Locating & Monitoring within Distribution Lines
8. Design a VI for RFID Automatic Identification & Database Management System
9. Measurement of level in a tank using capacitive type level probe

Essential/recommended readings:

Text Books:
1) Maurizio Di Paolo Emilio, “Data Acquisition Systems: From Fundamentals to Applied Design,” 2013, Springer.

2) H.R. Taylor, "Data Acquisition for Sensor Systems," 2010, Springer Science Business Media.
3) T. Karvinen, Kimmo Karvinen & Ville Valtokari, Make: Sensors, 2014, Shroff Publishers & Distributors.

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

GENERIC ELECTIVE COURSE – GE 01

Modern Engineering Applications of RF and Microwave Spectrum

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		
GE-01: Modern Engineering Applications of RF and Microwave Spectrum	4	3	1	0	Entry level	Basic Physics

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide an in-depth exploration of engineering applications which are being used in modern industries in the spectrum of RF and microwave.
- To provide basic knowledge of electromagnetic waves.
- To provide special attention will be given to the applications in remote sensing and controlling.
- To understanding the applications of microwave in communication. Last portion of this course deals with high power microwave applications and radiation hazards.

Learning Outcomes

At the end of this course, students will be able

- To have the basic knowledge of signals, frequency spectrum, and electromagnetic travelling waves.
- To understand the applications of radio waves in remote sensing and controlling.
- To evaluate the performance of microwaves in communication and defense.
- To develop the ability to understand the concept of high-power microwave signals radiation hazards.

SYLLABUS OF GE-01 — Total Hours: 45h

UNIT -I (11 Lectures)

Introduction to RF and Microwave: Signals, frequency and angular frequency, wavelength and velocity of waves in different mediums, Frequency Spectrums from extreme low-frequency to extreme high frequency, microwave frequency bands, electrical and magnetic signal, Faraday's Law, Generation of Electromagnetic (EM) Waves for static and time varying conditions, Travelling EM Waves; generation and characteristics, mechanism of dipole antenna, guided and un-guided medium, modes of propagation of EM waves.

UNIT – II (12 Lectures)

Applications in Remote Sensing and Controlling: RADAR, Light Detection and Ranging (LiDAR), Radio Frequency Identification (RFID), Remote Sensing; Active and Passive remote sensing, Moderate Resolution Imaging Spectroradiometer (MODIS), Remote Controlling, Internet of Things (I.O.T.), Advanced Driver Assistance System (ADAS).

UNIT – III (11 Lectures)

Applications in Communication; FM Radio, Television, Mobile phones, Bluetooth, WiFi, LiFi, Satellite Communication

Applications in defense, Stealth Technology, Applications in medical science, Applications in wearable technology, RF based Home appliances systems

UNIT – IV (11 Lectures)

High Power microwave signals: Generation of High-Power Microwave Signals; Klystron, Magnetron, High-power microwave weapons

RF radiations, Radiation Hazards, Electromagnetic Interference and Electromagnetic Compatibility (EMI/EMC).

Tutorial Component — Total Hours: 30h

- Addressing general queries of students.
- Practical numerical problems on frequency, wavelength and velocity.
- Demonstration of travelling EM waves and practical numerical problems.
- Demonstration of RADAR and practical numerical problems.
- Demonstration of ADAS and practical numerical problems.
- Demonstration of satellite communication and practical numerical problems.

Essential/recommended readings:

1. Sadiku, M. N. O. (2018). Elements of Electromagnetics (7th). Oxford University Press.
2. M. Skolnik "Radar Handbook," 3rd Edition, McGraw-Hill, Boston, 1990.
3. Basudeb Bhatta (2008), Remote Sensing and GIS, Oxford Higher Education.
4. Simon Haykin (2006), Communications Systems, 4th Edition, Wiley.

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

SKILL ENHANCEMENT COURSE – SEC-01

Fabrication & Testing Laboratory

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		
SEC-01: Fabrication & Testing Laboratory	2	0	0	2		Basic Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To devlope the entrepreneur skills in the students.
- To provide basic knowledge of tools and software's used in fabrication and testing.
- To provide the study of frequency effects on relative dielectric constant.

Learning Outcomes

At the end of this course, students will be able

- To design and fabricate the lumped PCB as well as high frequency planar circuits. Students will also be able to do the testing of developed circuits.

List of Experiments: Total Hours: 60h

[1] (i) Study of materials required for the fabrication of printed circuit for low and high frequency responses. Study of effect of frequency on relative dielectric constant and loss tangent of materials. (ii) Study of Surface Mount Technology (SMT) and Through Hole Technology (THT).

[2] Introduction of layout creation through different simulation software; (i) Autodesk Eagle, (ii) PCB Express, (iii) ADS, (iv) Auto-CAD, (v) CST Microwave studio/HFSS, (iv) any other open source software.

[3] Study of Photolithography Process; (i) Wafer cleaning, (ii) Photoresist application, (iii) Soft baking, (iv) Mask alignment, (v) UV Exposure, (vi) Development, (vii) Hard baking, (viii) Pattern transfer.

[4] To Study the instruments involved in PCB fabrication; (i) PCB Artwork Film Maker, (ii) PCB Curing machine, (iii) Photo Resist Dip Coating Machine, (iv) Proto-Dye/Developer, (v) Proto-Etch Etching Machine, (vi) Drilling Machine, (vii) Rollir Tinning Machine, (viii) UV Exposure Machine, (ix) PCB Shearing Machine, (x) soldering station

[5] Design and fabrication of electronic circuits using THT PCB and testing of fabricated circuit.

[6] Design and fabrication of Low pass/High pass/band pass filters and testing of fabricated circuit.

[7] Design, fabrication and testing of planar electronic component. Study of impedance matching and VSWR for high frequency designs.

[8] Design, fabrication and testing of a planar RF component.

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

SEMESTER-II

DISCIPLINE SPECIFIC CORE COURSE – DSC 04

Advanced Electronic Materials and Devices

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-04: Advanced Electronic Materials and Devices	**4**	**3**	**--**	**1**	**Entry level**	Basics of Semiconductor Devices and Materials, Semiconductor Physics and fundamentals of nano-materials

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide a comprehensive knowledge and concepts of the electronic materials used to fabricate micro/nano electronics.
- To provides the knowledge of flexible electronics for various applications such as optoelectronics, sensors and actuators.
- To demonstrate theoretical knowledge on semiconductors, flexible materials and their micro/nano structures for various potential applications

Learning Outcomes

At the end of this course, students will be able

- To overview and outlook of electronic industry and role various materials in daily human life.
- To understand the fundamental concepts of Organic and Inorganic Semiconductor materials, classification of materials.
- To apply quantum principles for nano structures.
- To understand various nano structures and determine how these structures impact the intended application.
- To understand the basic operating principles of various micro and nano electronic devices used in modern life style.
- To understand structural fundamentals of flexible materials for Wearable devices and IoT applications

SYLLABUS OF DSC-04 Total Hours: 45h

UNIT -I (11 Lectures)

Fundamentals for Electronic materials: Overview on classification and applications of Electronic materials**,** Energy band formation in Organic and Inorganic semiconductors, Electronic Defects and their Role in Device Operation, Transport in Semiconductors, Radiative and Non-Radiative Recombination, Minority Carrier Lifetime. Optical Absorption, Photoluminescence and Electroluminescence. Introduction to Wide Bandgap Electronic Materials.

UNIT – II (12 Lectures)

Heterostructures and Devices: Heterojunction Materials, Energy-Band Diagrams, Band offset, Two-Dimensional Electron Gas, Schottky barrier diodes, High-Speed Devices: HEMT, Tunneling Electron Transistors, Resonant Tunneling Devices. Transferred Electron Devices, Energy conversion and Energy Storage Devices.

UNIT – III (12 Lectures)

Nano structures and materials: Key concepts of nanostructures: De-Brogle Relation, Confined Electron in a Infinite and finite Potential Well, Tunneling Phenomenon. 2D, 1D and 0D structures: Quantum wells, wires, dots. Nanotubes, CNTs, 2D materials: graphene, BN, MXenes etc

UNIT – IV (10 Lectures)

Flexible Materials and Devices: Fundamentals of flexible materials, Smart and self-healing materials for stretchable electronics, Interfaces properties in flexible and stretchable electronic. Applications: Photovoltaic devices, Memory, Display, Energy harvester, Energy storage, Sensors and Actuators. Integrated Flexible Systems: Wearable health monitoring system, IoT sensors

List of Experiments: Total Hours: 30h

1. Determination the type of semiconductor and carrier concentration in the given doped semiconductor using Hall-effect
2. Determine resistivity and energy band gap of given semiconductor sample using four probe method.
3. To design a MOSFET as switching regulator for given duty cycle and Plot the Current-Voltage (I- V) characteristic of MOSFET using Keithley.
4. To design a phase-controlled rectifier using SCR and Plot the I-V characteristic of SCR using Keithley.
5. To design a relaxation oscillator using UJT and Plot the I-V characteristic of UJT using Keithley.
6. Plot the I-V characteristics of Schottky Diode using Keithley source meter and determine Ideality factor, Barrier Height, Series Resistance of the diode.
7. Plot the I-V characteristics of LED device using Keithley source meter and determine its Ideality factor.
8. Determine size of nano particle using LASER.

Essential/recommended readings:

1. S. O. Kasap, Principles of Electronic Materials & Devices, Mc Graw Hill Education., 4th Edition.
2. S. M. Sze and Kwok K. Ng., Physics of Semiconductor Devices, Willey, 2008, 3rd Edition.
3. W. Bruetting (Ed.), Physics of Organic Semiconductors, Wiley, 2005.
4. Neaman D. A., Semiconductor Physics and Devices, McGraw Hill, 2012, 4th Edition.
5. P. Bhattacharya, Semiconductor Optoelectronic Devices, 1995, PHI.
6. Ben G, Streetman and Sanjay Banerjee, Solid State Electronic Devices, 2005. PHI, 5th Edition.
7. Guzheng Shen, Zhidong Fan, Flexible Electronics: from Materials to Devices, 2016, World Scientific Publishing Co. Pte. Ltd.
8. W.S. Wong and A. Salleo, Flexible Electronics: Materials and Applications, Springer, 2010, (Electronic Materials: Science & Technology).

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

DISCIPLINE SPECIFIC CORE COURSE – DSC 05
Real Time Embedded System Design & IoT

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-05: Real Time Embedded System Design & IoT	**4**	**3**	**--**	**1**	**Entry level**	Microprocessor, Basic Programming

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop the knowledge and skills to design, develop, and implement systems that respond to real-time events and interact with the physical world.
- To Understand embedded software development, including programming languages (like embedded C), operating systems (RTOS), and real-time programming techniques.
- To understand the different layers of IoT architecture, including devices, gateways, networks, and cloud platforms.
- To understand how to collect, process, and analyze data from IoT devices.

Learning Outcomes

At the end of this course, students will be able

- To interface between microcontroller and peripheral devices.
- To understand the principles and functionalities of RTOS, including scheduling algorithms (priority-based, time-sliced), interrupt handling, task synchronization etc.
- To design and implement software for real-time embedded systems which control and monitor external hardware.
- To learn about the components of IoT architecture, and how to design IoT systems

SYLLABUS OF DSC-05 Total Hours: 45h

UNIT -I(13 Lectures)

Embedded Processor Architectures and Design: Introduction to embedded system (ES) & its classification, Components of embedded system, Application areas, Design parameters and architecture, Introduction to microcontrollers & its applications, ARM internal architecture, Addressing modes, ARM Instruction Set, PWM and Interrupts, Programmer`s model, Development tools.

UNIT – II (12 Lectures)

Programming & RTOS: Embedded C programming, Input/Output interfacing, Port formation and communication, Timer configuration and interrupts. Real Time Operating Systems(RTOS) fundaments and its usefulness.

UNIT – III (10 Lectures)

Internet of Things (IoT): Fundamentals of IoT & applications, Evolution of IoT, Various Platforms for IoT, potential & challenge, Real Time IoT examples, Overview of IoT components and IoT Communication Technologies.

UNIT – IV(10 Lectures)

Embedded system for patient monitoring: ECG, EEG, EMG, blood pressure, respiratory, pulse oximeters, diagnosis devices etc. Application of IoT in healthcare, agricultures and vehiculation**.**

List of Experiments: **Total Hours: 30h**

1. Write a program for Breathing LED with different rate.
2. Use the switch to select the LED (from RGB led) and then the potentiometer to set the intensity of that LED and thus create your own colour from amongst 16million colours.
3. Program to interface seven segment display from no. 0 to 99.
4. Program to interface keypad. Whenever a key is pressed, it should be displayed on LCD.
5. Program to interface stepper Motor to rotate the motor in clockwise and anticlockwise Directions
6. Program to control the speed of DC motor.
7. Program to read data from temperature sensor and display the temperature value on LCD.
8. Read the ADC value of the voltage divider involving the LDR. Print the value on the serial monitor.
9. Use the thermistor to estimate the temperature and print the raw value on the serial monitor.
10. Program to measure distance using IR/ ultrasonic sensor.

Essential/recommended readings:

1. Embedded Systems- Architecture, Programming and Design by Rajkamal, 2007, TMH.
2. The AVR Microcontroller and Embedded Systems, Second Edison, By, M. Mazidi
3. Advanced UNIX Programming, Richard Stevens
4. Embedded Linux: Hardware, Software and Interfacing – Dr. Craig Hollabaugh
5. Designing Embedded System and IoTs with the ARM Mbed, John Wiley & Sons Ltd. 2018.

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

DISCIPLINE SPECIFIC CORE COURSE – DSC 06

Electromagnetics, Antenna and Propagation

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-06: Electromagnetics, Antenna and Propagation	**4**	**3**	**–**	**1**	**Entry level**	**Basic Physics, Electrostatic and Magnetostatics, Maxwell's equations**

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand Maxwell's equations and their application in wave propagation across various media and guided structures.
- To analyze and model transmission lines using the RLCG model, and study different line configurations such as matched, open, short-circuit lines, and quarter-wave transformers.
- To explore waveguide modes (TE, TM, Hybrid) and their field distributions in rectangular and circular waveguides, dielectric slabs, and cavities.
- To familiarize with key antenna parameters and radiation mechanisms, and understand their impact on antenna performance and design.
- To investigate wireless propagation methods (ground, space, and ionospheric) and their importance in electromagnetic systems.
- To gain an understanding of link budget in ground transmission

Learning Outcomes

At the end of this course, students will be able

- To understand and apply Maxwell's equations and boundary conditions in EM wave propagation across various media.
- To analyze the propagation of EM waves in lossy and lossless dielectrics, including power and energy transfer.

- To solve transmission line problems using telegrapher's equations, including reflection, matching, and dispersion.
- To analyze waveguides and their modes, including rectangular and circular waveguides, for efficient EM wave transmission.
- To apply the Smith Chart for impedance matching and solve problems related to wave propagation in transmission lines.
- To understand radiation mechanisms and key antenna parameters such as polarization, radiation patterns, and beamwidth.
- To understand various types of antennas, including dipole, microstrip, and horn antennas.
- To investigate wireless propagation methods including ground wave, space wave, and ionospheric propagation.

SYLLABUS OF DSC-06 Total Hours: 45h

UNIT -I (11 Lectures)

Electromagnetic (EM) Wave Propagation in different media: Maxwell's equations, constitutive relations, Boundary conditions, Helmohtz equation, plane wave functions, wave propagation in lossy dielectric (sea water), plane waves in lossless dielectrics, power and Poynting vector, EM wave interaction with different media at normal/oblique incidences, and reflection & refraction due to change of media, Microwave Absorber.

UNIT – II (11 Lectures)

EM wave propagation in Transmission line structures: Telegrapher's equations in time and frequency domain, losses and dispersion, reflection from an unknown load; quarter wavelength line, half wavelength lines, Left hand, Right handed transmission lines, single stub matching; Smith Chart and its applications, Different transmission lines like Coaxial lines, Microstrip, Strip lines, Slot lines, Co-planar Waveguide (CPW).

UNIT – III (12 Lectures)

EM wave propagation in Guided wave structures: Field components in rectangular waveguide, Bessel's functions and circular waveguide, Dielectric loaded waveguides, dielectric slab waveguide surface guided waves, Analysis of various supporting Modes, waveguide components.

UNIT – IV (11 Lectures)

Radiating Structures and wireless propagation: Radiation mechanism, Antenna parameters: Radiation pattern, Major Lobe, Side Lobes, Side lobe level (SLL), Back Lobe, Half power beamwidth, Polarization, Co and Cross Polarization, radiation from simple dipole and aperture, concept of antenna, arrays, end-fire and broadside arrays, horn antenna, microstrip antenna, parabolic disc antenna. Ground wave, space wave and ionospheric propagation, Communication link budget for ground transmission.

List of Experiments: **Total Hours: 30h**

1. Study of Electromagnetic Spectrum and Microwave Components used Microwave Bench.
2. Study of VI Characteristics of Gunn Diode using Microwave Test Bench, Also, find the all possible transmitting modes at operating frequencies.
3. Study of attenuation using variable attenuator on Microwave Test Bench
4. Measurement of Frequency, Guided Wavelength, VSWR, using Microwave Bench
5. Measurement of Low and High VSWR for Matched, Short, and Open Termination
6. Measurement of S-Parameters matrix for Magic Tee using Microwave Test Bench
7. Estimation of unknown impedance (IRIS) used to terminate the line (slotted section) by VSWR measurements (shift in minima position method)
8. Estimation of Near and Frafield and measurement of the dimensions of the HORN Antenna.
9. Measurement of Radiation Pattern for HORN antenna Using Microwave Test Bench

Essential/recommended readings:

1. D. K. Cheng, "Field and Wave Electromagnetics," 2nd Edition, Addison Wesley
2. Matthew N. O. Sadiku, "Principles of Electromagnetics"Oxford University Press
3. Kraus, Daniel A. Fleisch, "Electromagnetics: With Applications", WCB/McGraw-Hill
4. C.A. Balanis, "Advanced Engineering Electromagnetics," John Wiley & Sons
5. C.A Balanis, “Antenna Theory Analysis and Design”, John Wiley & Sons, February 2016

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DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 05

RF and Microwave Components

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		
DSE-05: RF and Microwave Components	**04**	**03**	**–**	**01**	**Entry level**	**Foundation in circuit analysis, electromagnetics, and transmission lines.**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide knowledge of RF and microwave technology in developing mobile communication, satellite, and RADAR systems.
- To provide schematics and working of microwave passive and active components.
- To design the concept for RF and microwave components
- To enable students to use their expertise in the relevant industry and R & D institutions.

Learning Outcomes

At the end of this course, students will be able

- To understand the basic concepts of microwave network theory and the behavior of the microwave components.
- To learn the requirements of impedance matching and techniques.
- To understand the working of microwave passive and active components.
- To learn the characterization methods at the microwave frequencies.
- To gain knowledge about applications of RF and microwave components.

SYLLABUS OF DSE-05 Total Hours: 45h

UNIT -I (09 Lectures)

Introduction to microwave networks: Overview of RF system design, distributed transmission lines, microwave network analysis, scattering parameters, ABCD parameters, ABCD to S-parameters conversion, T- network and Pi-network, Attenuator design, Cascaded network.

UNIT – II (12 Lectures)

Passive components I: Planar transmission lines, Even-odd modes, Impedance matching; L-network, quarter wave transformer design; tapered lines; Transmission line resonators; RF switch; Microstrip filters; Insertion loss method; Low-pass prototype; High-pass, band pass, and band stop filters; coupled line filters, Characterization of the filters.

UNIT – III (12 Lectures)

Passive components II: Resistive power divider, Wilkinson power divider, Equal and unequal power divider, Isolator, Circulator, Diplexer, Duplexer, 3-port and 4-port directional coupler, Branch-line coupler, Rat-race coupler.

UNIT – IV (12 Lectures)

Active components: Basics of Microwave Diodes and Transistors, Gunn diode, Tunnel diode, IMPATT diode, TRAPATT diode, BARITT diode and PIN diode, Microwave FET, HEMT. Overview of microwave amplifier, oscillator, and mixer.

List of Experiments: Total Hours: 30h

Simulation and Vector network analyzer-based Measurement of Microwave passive components.
1. To design and simulate the matching networks.
2. To design and simulate the microstrip low-pass and high-pass filters.
3. To design and simulate the microstrip band-pass and band-stop filters.
4. To design and simulate the power dividers.
5. To design and simulate the directional couplers.
6. To measure and study the characteristics of microwave filters.
7. To measure and study the characteristics of microwave power dividers.
8. To measure and study the characteristics of microwave directional couplers

Essential/recommended readings:

1. G. Kennedy, D. Bernard and S. R. M. Prasanna, Electronic Communication Systems, McGraw Hill Publication, 2017, 6th edition.

2. Subal Kar, Microwave Engineering: Fundamentals, Design, and Applications, Universities Press, 2016.

3. S. Y. Liao, Microwave Devices and Circuits, Pearson Education, 2003, 3rd edition.

4. D. M. Pozar, Microwave Engineering, John Wiley & Sons, Inc., 2012, 4th edition.

5. A. Das and S. K. Das, Microwave Engineering, Tata McGraw Hill, 2000.

6. S. Kumar and S. Shukla, Concept of Microwave Engineering, PHI Learning Pvt. Ltd., 2014.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 06

CMOS Digital Integrated Circuit Design

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		
DSE-06: CMOS Digital Integrated Circuit Design	4	3	–	1	Entry level	Basic Digital Electronics

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide students with rigorous foundation in MOS and CMOS devices and circuits.
- To train students to enable them to design and analyze circuits using VHDL/ Verilog
- To provide students hands-on skills in layout design
- To provide exposure to students and to equip them for semiconductor and VLSI industry, R & D organization in the area of microelectronics.

Learning Outcomes

At the end of the course student will be able

- To implement the logic circuits using MOS and CMOS technology.
- To design and analyze circuits using hardware descriptive languages.
- To understand the design of memories.
- To use the EDA tools for circuit simulation, layout verification and parasitic extraction.

SYLLABUS OF DSE-06 Total Hours: 45h

UNIT -I (12 Lectures)

Introduction to VHDL/Verilog: Introduction to VHDL/Verilog Programming language, data objects, classes and data types, Operators, Overloading, and logical operators. Types of delays Entity and Architecture declaration, Introduction to behavioral, dataflow and structural models Application of Functions and Procedures, Structural Modelling, component declaration, structural layout and generics

UNIT – II (12 Lectures)

MOS inverter design: Voltage transfer characteristics, logic threshold, inverter with resistive, enhancement and depletion loads – calculation of critical voltages, noise margins, power consumption and chip area considerations, noise margin, transit time and inverter delay; CMOS inverter: calculation of critical voltages, noise margins; analysis of an nMOS Inverter driven by another nMOS Inverter, nMOS inverter driven through pass transistors, ring oscillator, switch level RC delay model

UNIT – III (12 Lectures)

CMOS logic Design: Combinational and sequential CMOS logic design, OAI and AOI logic circuits, voltage bootstrapping

Semiconductor MOS memories: Static Random Access Memories (SRAMs), SRAM Cell Structures, MOS SRAM Architecture, 6T SRAM cell design, read & write operation, DRAM architecture, DRAM cell

UNIT – IV (09 Lectures)

Verification and reliability analysis: MOS layers, Stick diagrams, CMOS design rules and layout design

Verification methodologies, logic verification, physical verification**,** Lambda and micron design rules, DRC, layout versus schematic checks, electrical rule check, antenna check, electromigration, time dependent dielectric breakdown, negative bias temperature instability, latch-up

List of Experiments: **Total Hours: 30h**

1. Design gates using VHDL/ Verilog
2. Design a half adder and full adder using VHDL/ Verilog
3. Design a counter using VHDL/ Verilog
4. Design a MUX using VHDL/ Verilog
5. Design an nMOS inverter with various loads and study the characteristics
6. Design a CMOS inverter and study its characteristics
7. Draw the stick diagram of basic gates and nMOS inverters
8. Draw the stick diagram of CMOS inverter and create the layout
9. Perform design rule checks of basic gates and inverters
10. Perform layout check and post layout simulation for CMOS inverter and extract parasitic.

Essential/recommended readings:

1. J. Bhasker : A Verilog HDL Primer, BSP, 2003, ISBN: 9788178000114, 9788178000114
2. Samir Palnitkar : Verilog HDL-A guide to digital design and synthesis-, Pearson, 2003, ISBN-10 8177589180, ISBN-13 978-8177589184
3. Wayne Wolf : Modern VLSI Design: IP-Based Design, PHI, 2008, ISBN-10 0137145004; ISBN-13 978-0137145003
4. Weste and Harris: CMOS VLSI Design: Circuits and Systems Perspective, Addison-Wesley,2015, ISBN-10 9789332542884; ISBN-13 978-9332542884
5. Kang and Lebelbigi: CMOS Digital IC Circuit Analysis and Design, McGraw Hill, 2002, ISBN-10 0072460539; ISBN-13 978-0072460537
6. Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic: Digital Integrated Circuits: A Design Perspective, Prentice Hall Electronics, 2003, ISBN-10 0130909963; ISBN-13 978-0130909961

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 07
Opto-Electronics

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		
DSE-07: Opto-Electronics	4	3	–	1	Entry level	Ray Optics and Wave Optics

Learning Objectives

The Learning Objectives of this course are as follows:

- To gain a comprehensive understanding of the Electrodynamic Theory of Light, including electromagnetic theory, energy transport, and polarisation states using Stokes and Jones formalisms.
- To learn about polarisation optics, covering Jones vector and matrix transformations, elliptically polarised states, and the Poincare sphere representation.
- To explore photonic detectors and instruments, including thermal and quantum detectors, various photoelectric devices, and optical instruments like spectrometers and interferometers.
- To learn technical knowledge of crystals, their optical properties, and the sensors.

Learning Outcomes

At the end of this course, students will be able

- To analyse and describe the polarisation states of light using Stokes and Jones formalisms.
- To apply Jones vector and matrix transformations to understand polarisation optics.
- To identify and explain the operation of various photonics detectors and optical instruments.
- To describe the principles of optical waveguides and thin film optical devices.
- To skill of MEEP simulation software.

SYLLABUS OF DSE-07 Total Hours: 45h

UNIT -I (11 Lectures)

Electrodynamic Theory of Light: Electromagnetic theory of light, Wave-Particle Duality of Light, Energy Transport - Polarization States- Strokes and Jones Formalism, Polarization Optics, Transformation of Jones Vectors and Matrices, Elliptically Polarized States, Poincare Sphere. Inhomogeneous Waves and Fresnel equations.

UNIT – II (12 Lectures)

Optical Components and Thin Film - Optical Waveguide, Dielectric Interface, Optical Coupler, Optical Divider, Reflection from a Metallic Surface, Anti-reflection Coating, Multilayer Dielectric Mirror, Beam Splitter and Optical Gates. Thin Film Optical Sensors. Introduction to MEEP simulation platform.

UNIT – III (10 Lectures)

Anisotropic Media and Crystal Optics: Plane waves in anisotropic media, wave refractive index, uniaxial and biaxial media, wave plates and analysis of polarised light, electro-optic effect acousto-optic effect, application to modulators. Quantum Cryptography and Optics.

UNIT – IV (12 Lectures)

Optical Detectors and Instruments: Thermal and Quantum Detectors. Application of Spectroscope and Characterization using Spectroscopic Techniques, Type of Spectrometer. Working of Refractometers, Monochromator, and Michelson Morley Interferometer.

List of Experiments: Total Hours: 30h

1. Measurement of Polarizer and Analyzer, Half Wave Plate and Quatre Wave Plate using Power Meter.
2. Measurement of LEDs Gaussian profile and Gratings effect Laser Lights.
3. To measure the wavelength of spectral lines of Hydrogen Emission and its Absorption Spectra.
4. To measure the wavelength of spectral lines of iodine (I_2) source using diffraction grating and spectrometer.
5. Designing a webcam spectrometer for Emission and Absorption Spectra.
6. Measurement of Quantum Cryptography Entanglement.
7. Simulation of Fields in a Waveguide for a straight waveguide and 90° bend using MEEP.
8. Simulation of Modes of a Ring Resonator using MEEP.

Essential/recommended readings:

1. Degiorgio, Vittorio, and Ilaria Cristiani, Photonics, Springer, 2015.
2. Ganguly, Amar K. Optical and Optoelectronic Instrumentation, Alpha Science International, Limited, 2010.
3. Ajoy Ghatak, Optics, Multicolor Edition, McGraw Hill, New Delhi, 2000.
4. Mukherji, Uma, Engineering Physics, Alpha Science International Limited, 2007.
5. Reider, Georg A, Photonics, Springer, 2016.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 08

Terahertz Technology 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		
DSE-08: Terahertz Technology and Applications	4	3	–	1	Entry level	Basic Physics, Electrostatic and Magnetostatics, Optics.

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand why the THz range is important for science and technology.
- To understand why this field was underdeveloped.
- To learn about different THz sources with their advantages, disadvantages and limitations.
- To learn about different THz detection methods.
- To understand the principle of broadband THz time-domain spectroscopy.
- To grasp the scope of numerous THz applications.

Learning Outcomes

At the end of this course, students will be able

- To understand terahertz Technology Fundamentals:
- To use the application of Terahertz Sources and Detectors
- To use passive components such as Terahertz Antennas, splitters, combiners, polarizers, etc.
- To use application areas of Terahertz Technology.
- To use terahertz time-domain spectroscopy (thz-TDS), Terahertz sensing and non-destructive testing.

SYLLABUS OF DSE-08 Total Hours: 45h

UNIT -I (10 Lectures)

Introduction to terahertz technology, The concept of terahertz gap, Frequency Spectrum, Terahertz Principles, Key technological issues for Terahertz technology, Fundamental limits, Terahertz technology Applications and opportunities.

UNIT – II (12 Lectures)

Terahertz Sources and Detectors: Terahertz pulse generation using photo-mixing and laser interferometry, overview of semiconductor technology, Terahertz power generation in Silicon technology, working principle of HEMT and DHBT, Si-Ge HBT, III–V/Schottky diode-based diode detectors, planar and spatial power combining techniques, direct detection versus heterodyne detection, transistor detector circuits, active and passive mode detection.

UNIT – III (12 Lectures)

Terahertz passive components: Terahertz Microstrip Antenna, Terahertz photoconductive antenna, Terahertz Onchip Antenna, Terahertz Sensors, splitter, combiner, polarizer, isolator, diplexer, directional couplers, open resonator design, Bragg reflector, tunable properties for Terahertz devices using Graphene, liquid crystals.

UNIT – IV (11 Lectures)

Application of Terahertz: Terahertz time-domain spectroscopy (THz-TDS), Terahertz sensing and non-destructive testing, Material analysis Application, Molecular analysis application, THz imaging and tomography, Pharmaceutical analysis application

List of Experiments: **Total Hours: 30h**

1. Study of the Frequency Spectrum of Electromagnetic Spectrum and Terahertz Gap with their application and challenges.
2. Study of various sources and detectors of Terahertz
3. Study and Design of Terahertz sensor Using Vanadium dioxide (VO_2)
4. Study and Design of Photo Conductive Sensor
5. Study and design of Terahertz Microstrip Antenna
6. Study and Design of Photo Conductive Terahertz Antenna
7. Study and Design of Power Splitter
8. Study and Design of Filters

Essential/recommended readings:

1. J.S. Rieh, “Introduction to Terahertz Electronics,” Springer, 2001
2. Yun-Shik Lee, "Principles of terahertz science and technology" (Springer, 2009).
3. R. E. Miles, P. Harrison, and D. Lippens, “Terahertz Sources and Systems,” NATO Science Series.
4. E. Bruendermann, H-W. Huebers, M.F. Kimmitt, "Terahertz Techniques", Springer Series in Optical Sciences 151 (Springer, 2012)
5. D. W. Woolard, W. R. Loerop, and M. S. Shur, “Terahertz Sensing Technology,” World Scientific
6. J. M. Chamberlain and R. E. Miles, “New Directions in Terahertz Technology,” NATO ASI Series
7. P. F. Goldsmith, “Quasi-Optical Systems,” IEEE Press Series

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

GENERIC ELECTIVE – GE-02

Introduction to Brain-Computer Interface

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		
GE-02: Introduction to Brain-Computer Interface	4	3	1	-	Entry level	Knowledge of Basic Sciences and Mathematics

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the Physiology of the Human Brain.
- To measure the Bio Signal in response to Various cognitive loads.
- To understand the Role of Signal theory in explaining Brain Signals.
- To describe the synchronization and desynchronization phenomenon of neural Circuit.
- To develop the user interface for neurorehabilitation.

Learning Outcomes

At the end of this course, students will be able

- To describe the Physiology of the Human Brain.
- To identify the Cognitive State Estimation Problem.
- To transformation of Brain Signal in Frequency Domain.
- To quantify the phenomenon of ERD and ERS of the Neural Circuit.
- To develop a paradigm for the User Interface.

SYLLABUS OF GE-02 Total Hours: 45h

UNIT -I (10 Lectures)

Brain Structures and Scalp Potentials, Neural Activities, Measuring Electric Activity in the Brain, Methods of Acquiring Brain Signals, Brain Signal Modelling, Brain Rhythms. Event-Related Potentials

UNIT – II (10 Lectures)

10-20 Electrode Placement System, EEG Recording and Measurement, Artefact, Spatial Filter, Common Spatial Pattern, Laplacian Referencing, Common Average Referencing. Cognitive State Estimation Problem.

UNIT – III (15 Lectures)

Signals and Systems; Linear Algebra Basics-Vectors, Orthogonality, Eigenvalues and Eigenvectors. Classification of Signals, System Properties, Continuous Signals and Systems, Sampling, Signal Transformation, Transfer Functions, Causality, Stability, Convolution, Digital Filter, Spectral analysis (FFT-based)

UNIT – IV (10 Lectures)

BCI Inference system, BCI Paradigm, ERD and ERS, BCI performance Evaluation parameters, Feature Extraction (Time domain and Frequency domain), Linear classification.

Tutorial Component **Total Hours: 15h**

- To learn about the fundamentals of the Human Brain and mathematical modelling of it.
- To measure the response of the brain Activity using an electronic system.
- To explore different rhythmic bands.
- To explain concept of signal, system, and filtering with MATLAB simulation.
- To develop a machine learning classification algorithm.
- To demonstrate the BCI system.

Essential/recommended readings:

Textbooks:

1. Saied Sanei and J.A. Chambers, EEG Signal Processing, John Wiley & Sons Ltd., 2007.

2. Guido Dornhege, Jos´e del R. Mill´an Thilo Hinterberger, Dennis J. McFarland, KlausRobert Muller,
   Toward Brain-Computer Interfacing, MIT Press Cambridge, 2007.

3. Rangaraj M. Rangayyan, Biomedical Signal Analysis- A case-study approach, IEEE Press, 2005.

4. D.C. Reddy, Biomedical Signal Processing – principles and techniques, Tata McGraw-Hill, New Delhi, 2009.

Reference books:

1. Simon Haykin "Neural Networks: A Comprehensive Foundation" – Pearson Education, 1998

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

SKILL ENHANCEMENT COURSE – SEC-02

Embedded-IoT Product Development and Testing

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		
SEC-02: Embedded-IoT Product Development and Testing	**2**	**0**	**0**	**2**	**Entry level**	**Basic knowledge of Microprocessor**

Learning Objectives

The Learning Objectives of this course are as follows:

- To study of embedded system which is one of the major focus areas in electronics supported by relevant projects.
- To devlope the entrepreneur skills in the area of embedded system product and also in IoT product.
- To design the embedded system and IoT in real time applications.

Learning Outcomes

At the end of this course, students will be able

- To design and fabricate the embedded and IoT based projects using various sensors and advanced microcontroller.
- To use different types of sensors are designed, implemented, and interfaced with embedded systems to collect physical data from the environment.
- To use Integrated Development Environment for real time design of embedded projects.

List of Experiments: Total Hours: 60h

1. The study of smart sensors used in embedded systems that will focuses on understanding how different types of sensors are designed, implemented, and interfaced with embedded systems to collect physical data from the environment, converting it into electrical signals that can be processed by the system to make informed decisions or trigger actions based on the sensed information.
   i. Physical Sensors
   ii. Chemical Sensors
   iii. Biological Sensors
2. Introduction of IDE (Integrated Development Environment) that provides a comprehensive set of tools for writing, compiling, debugging, and managing the embedded software project.
   1. Keil MDK (Microcontroller Development Kit),
   2. MPLAB X IDE from Microchip,
   3. Visual Studio,
   4. Arduino IDE.
3. Study of Programming Languages and their instructions for embedded system.
4. Study the process of connecting and controlling physical devices like sensors, actuators, displays, and other external components to a microcontroller within an embedded system, allowing it to interact with the physical environment and perform real-world tasks like measuring temperature, controlling motors, or displaying data on a screen; essentially bridging the gap between the digital world of the microcontroller and the analog world of physical sensors and actuators.
5. Design and Testing of RFID based Security System.

7. Design and Testing of speed monitoring system.
8. Design and testing of Embedded System for Hazardous Gas Detection and Alerting.
9. Design and Testing of Embedded System for monitoring of ECG,EEG for telemetry.
10. Design and Testing of Embedded System for environment monitoring.
11. Design and Testing of Embedded System for soil monitoring.

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

UNIVERSITY OF DELHI

MASTER OF SCIENCE IN INFORMATICS

(M.Sc. Informatics)

(Effective from Academic Year 2025-26)

PROGRAMME BROCHURE

Institute of Informatics & Communication (IIC) University of Delhi South Campus New Delhi – 110021

As approved in the faculty meeting on ________

For consideration to FIAS.

1/4/25

Dean, FIAS

CONTENTS

About IIC

The Institute of Informatics & Communication (IIC) was established in 1997 with the vision of integrating diverse fields of Information Technology (IT) and adapting to the ever-evolving digital landscape. Over the years, IIC has continuously evolved to incorporate emerging trends and cutting-edge technologies, keeping pace with advancements in the industry. Initially focusing on computer hardware, software development, and telecommunications, the institute has expanded its expertise to include Cloud Computing, Generative AI (GAI), Cybersecurity, and Digital Transformation.

IIC is not only committed to academic excellence but also actively contributes to technology-driven societal advancements. The institute fosters an environment where innovative ideas thrive while maintaining respect for traditional knowledge. It also engages in product development and research initiatives that contribute to the digitalization of India and creates solutions that benefit both industry and society.

Our Objectives

IIC was founded with the following key objectives:

- To serve as an interdisciplinary center that bridges science, technology, humanities, and industry, ensuring students receive a well-rounded education.
- To offer an industry-relevant and socially impactful postgraduate program that is designed to equip students with advanced knowledge and practical skills.
- To conduct high-quality research and innovation in informatics, communication, AI, cybersecurity, and emerging technologies.
- To continuously revise and update the curriculum in line with technological advancements and industry demands.
- To support entrepreneurial initiatives, product development, and innovative solutions that contribute to the digital growth of India.

M.Sc. Informatics: A Future-Ready Program

IIC offers a M.Sc. (Informatics) degree program, designed to provide students with a strong foundation in advanced computing, AI, cybersecurity, and data-driven technologies. The curriculum blends theoretical knowledge with hands-on experience and prepares students for high-demand careers in IT, research, and emerging tech industries. The program fosters critical thinking, problem-solving abilities, and innovation and ensures graduates stay ahead in the rapidly evolving tech landscape.

Learning Approach and Skill Development

IIC follows a **dynamic and forward-thinking learning approach**, which includes:

- Classroom lectures, tutorials, and hands-on lab sessions ensure a balance between theory and practical application.

- Exposure to the latest trends in AI, cybersecurity, blockchain, and cloud computing, prepares students for modern technological challenges.
- Regular seminars, industry collaborations, and research projects, where students present ideas, improve communication skills, and engage with experts.
- Encouragement of innovation, entrepreneurship, and product development, allowing students to work on solutions that benefit society and support India's digital transformation.

Admission to the M.Sc. Informatics program is highly competitive, with a rigorous selection process ensuring that only the most dedicated and talented students join. IIC is committed to fostering a culture of research and excellence, collaborating with leading national and international institutions on cutting-edge projects. The institute's faculty and researchers have published extensively in top scientific journals, developed technological solutions for real-world challenges, and contributed to prestigious global conferences. Through its future-ready curriculum, strong research foundation, and industry partnerships, IIC remains at the forefront of technological innovation, shaping the next generation of leaders in informatics and communication technologies.

Programme Objectives (POs)

The Institute of Informatics and Communication offers a modern and competitive study program designed to align with global advancements in Informatics, Telecommunications, Artificial Intelligence (AI), and Cybersecurity. The curriculum integrates international standards set by leading scientific and professional associations, such as the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers (IEEE). The program provides a strong scientific foundation and specialized knowledge, ensuring that graduates are well-equipped to meet the growing demands of the industry. It incorporates faculty expertise, industry feedback, and insights from external evaluations to deliver a future-ready education.

Key Objectives of the Program

- Foster a stimulating and engaging learning environment that excites students about their chosen field of study.
- Build strong theoretical and practical knowledge in Informatics, Telecommunications, Artificial Intelligence, Cybersecurity, and related technologies.
- Equip students with the skills and expertise needed to excel in industry roles, research, and innovation-driven careers.
- Provide insights into the latest advancements in AI, Big Data, Cloud Computing, Blockchain, Cybersecurity, and Quantum Computing.
- Offer education through a diverse range of activities, including laboratory work, industry collaborations, hackathons, internships, and project-based learning.
- Prepare students for advanced research and development (R&D) in AI, Cybersecurity, Data Science, and Emerging Technologies.
- Develop the ability to analyze, design, and implement scientifically sound solutions for real-world challenges in Intelligent Computing & Secure Networks.

Programme Learning Outcomes (PLOs)

Graduates of the Institute of Informatics and Communication will be well-equipped with comprehensive knowledge and practical skills. They will possess the ability to analyze, design, develop, and manage advanced ICT systems and applications, while also being prepared for lifelong learning, research, and professional growth in the ever-evolving digital landscape.

Knowledge and Understanding

- Develop a strong foundation in advanced computing and network security and skill them to design innovative, scientifically grounded ICT solutions.
- Understand the economic, managerial, and business aspects of running projects related to Informatics and Telecommunications.
- Recognize and address ethical, social, legal, and educational concerns related to emerging technologies such as AI ethics, data privacy, cybersecurity policies, and digital transformation.

Application of Knowledge and Practical Skills

- Apply theoretical knowledge in modern information systems, digital networks, cloud computing, IoT, and big data analytics.
- Possess practical skills in AI, machine learning, data-driven decision-making, and cybersecurity threat analysis.
- Develop sector-specific solutions for industries including healthcare, finance, smart cities, and digital forensics.
- Identify and effectively apply the right tools, frameworks, and programming languages to solve complex problems in data science, AI, blockchain, and edge computing.
- Conduct experiments, simulations, and data-driven research, analyze results, and interpret key findings using statistical and computational techniques.
- Work independently and collaboratively in cross-functional teams to design, develop, test, and optimize ICT systems.

Critical Thinking and Problem-Solving

- Identify, analyze, and solve problems related to the design, management, and evolution of ICT systems using AI and computational intelligence techniques.
- Conduct performance evaluation and benchmarking of hardware and software systems.
- Assess the efficiency, scalability, and robustness of AI and data-driven solutions.
- Critically evaluate scientific and technical publications, keeping up with breakthroughs in areas such as quantum computing, federated learning, and cybersecurity resilience.
- Understand the limitations of technology, its impact on society, and their ethical responsibility in its implementation, considering social, economic, environmental, and policy perspectives.
- Continuously update their knowledge to stay ahead in the rapidly evolving fields of AI, data science, and cybersecurity.

Communication and Collaboration

- Communicate technical concepts, problems, and solutions effectively through reports, presentations, and discussions.
- Work collaboratively in multidisciplinary teams, contributing to project design, system implementation, and performance optimization.
- Produce technical reports, research papers, and executive summaries for decision-making in AI-driven and data-intensive environments.

Lifelong Learning and Future Readiness

- Adapt to new methodologies, frameworks, and computational tools throughout all phases of an ICT system's lifecycle.
- Stay updated with scientific and technological advancements in AI, cybersecurity, blockchain, and data analytics.
- Continuously upgrade their skills through self-learning, certifications, and higher studies in advanced informatics and communication technologies.

- Be prepared for further research and development (R&D) in emerging fields like Explainable AI (XAI), Green Computing, and Human-AI Collaboration.

Programme Specific Outcomes (PSOs)

The MSc Informatics program is structured to provide a strong theoretical foundation, practical expertise, and industry-relevant skills across four semesters. Throughout the program, students develop technical proficiency, research aptitude, and problem-solving skills, enabling them to tackle complex challenges in Informatics, AI, and Cybersecurity. The structured blend of core courses, electives, and hands-on labs ensures graduates are well-prepared for industry roles, academic research, and entrepreneurial ventures in emerging technologies.

First Semester

The first semester establishes a strong foundation in Artificial Intelligence, Operating Systems, and Data Science, along with elective choices that allow students to tailor their learning based on their interests. The Computational Data Science Lab provides hands-on experience in data-driven problem-solving.

- **Artificial Intelligence: Principles and Techniques**
  Understanding fundamental AI concepts, search algorithms, knowledge representation, and machine learning techniques.
- **Operating Systems**
  Study of OS principles, process management, memory management, file systems, and security.
- **Data Science & Big Data Analytics**
  Techniques for handling large-scale data, statistical methods, machine learning applications, and distributed computing frameworks like Hadoop & Spark.
- This program offers flexibility for students to explore specialized elective courses based on student interest. Students may choose either a second DSE or a General Elective (GE) from the available options.
- **Computational Data Science Lab**
  Practical implementation of data science techniques, AI models, and big data frameworks through hands-on exercises and real-world datasets.

This semester provides a balanced mix of theoretical foundations, computational techniques, and practical skills, preparing students for advanced AI-driven problem-solving and research.

Second Semester

The second semester builds on foundational concepts by introducing Advanced Data Structures, Computer Networks, and Database Management, along with elective flexibility to allow students to tailor their learning. The Data Management & Optimization Lab provides practical exposure to handling large-scale data and optimizing computational workflows.

- **Advanced Data Structures**
  In-depth study of data organization techniques, graph algorithms, dynamic programming, and advanced tree structures.
- **Computer Networks and Communication**

Concepts of network architecture, protocols, data transmission, security, and emerging trends in communication networks.

- ❖ **Database Management & NoSQL Technologies**
  Covers relational database design, query optimization, transaction management, and modern NoSQL databases like MongoDB, Cassandra, and Redis.
- ❖ A specialized elective course tailored to the student's chosen domain. Students can either continue with a **DSE** or opt for an **interdisciplinary GE** from another department.
- ❖ **Data Management & Optimization Lab**
  Hands-on experience with database design, query execution, distributed computing frameworks, and performance optimization techniques.

This semester strengthens students' expertise in data-driven technologies, networking, and advanced computational techniques, preparing them for cutting-edge industry roles and research opportunities.

Third Semester

The third semester focuses on advanced topics in AI, machine learning, and cybersecurity while allowing students to explore specialized electives. The Deep Learning & Advanced Analytics Lab provides hands-on experience with state-of-the-art AI techniques.

- ❖ **Cybersecurity Risk Management & Compliance**
  Covers risk assessment methodologies, compliance frameworks (ISO 27001, NIST, GDPR), ethical hacking, and security governance.
- ❖ **Advanced Topics in Machine Learning and AI**
  Explores cutting-edge ML techniques, generative AI, reinforcement learning, explainable AI (XAI), and AI ethics.
- ❖ Elective courses focusing on **emerging technologies and research-oriented topics**.
- ❖ **Deep Learning & Advanced Analytics Lab**
  Hands-on implementation of deep learning architectures (CNNs, RNNs, transformers), reinforcement learning, AI-driven analytics, and scalable AI models.

This semester strengthens expertise in cybersecurity, AI research, and advanced analytics, equipping students with the skills needed for industry roles and academic research in cutting-edge AI and security fields.

Fourth Semester

The fourth semester focuses on advanced computing paradigms, information system design, and quantum computing, along with specialized electives. The Web Applications & Services Lab provides hands-on experience in developing scalable web solutions.

- ❖ **Information System Design and Management**
  Covers system analysis, architecture design, IT governance, enterprise information systems, and strategic IT management.
- ❖ **Quantum Computing Fundamentals**
  Introduction to quantum mechanics, quantum algorithms (Shor's, Grover's), quantum cryptography, and quantum machine learning.
- ❖ Students can opt for three DSEs or choose two DSEs and a GE based on their interests.

❖ **Web Applications & Services Lab**
Hands-on experience with full-stack development, cloud-based services, API development, and modern web frameworks (React, Node.js, Django, etc.).

This semester provides a comprehensive understanding of system design, quantum computing, and web technologies, preparing students for industry roles in software development, AI, cybersecurity, and advanced computing research.

Educational Approach and Laboratory Integration

The MSc Informatics program ensures that each course across all four semesters is closely integrated with dedicated hands-on laboratory experiments. This practical approach enhances students' understanding by enabling them to apply theoretical concepts to real-world problems through structured laboratory work. IIC always designs the educational methodology to develop critical thinking, analytical skills, and collaborative problem-solving abilities. The learning process encourages students to:

- Analyze complex scientific and technological problems and develop practical solutions.
- Work independently and in teams, effectively coordinating and managing group projects.
- Engage actively in lectures, laboratory sessions, and project-based learning.

Classroom and laboratory sessions form a crucial part of the learning experience. These sessions provide a platform where students and faculty exchange knowledge, share experiences, and enhance learning collectively. To fully benefit from this approach, students are expected to:

- Attend lectures and lab sessions regularly as per the schedule.
- Arrive on time and actively participate in discussions and practical exercises.
- Engage in the complete learning process to grasp both theoretical and applied aspects of the subject.

IIC integrates modern e-learning tools to complement traditional classroom teaching. These include:

- Online lecture notes and educational materials.
- Digital platforms for project submissions and academic announcements.
- Supplementary learning resources for deeper exploration of course content.

However, while these digital tools enhance the learning process, they cannot replace physical presence in lectures, laboratories, or assessments. Participation in hands-on activities, in-class discussions, and laboratory-based evaluations remains essential to achieving academic success. Students are required to follow the course timetable and adhere to faculty instructions to ensure they gain maximum benefit from the program’s interactive and experiential learning approach.

Program Structure

The PG Curricular Framework 2024, based on the National Education Policy (NEP) 2020, emphasizes a flexible, multidisciplinary, and research-driven approach to postgraduate education.

It is structured to cater to diverse academic and professional aspirations while maintaining global standards in higher education.

Level 6: First Year of PG (Two-Year PG Programmes - 3+2 Structure)

The **first year of a two-year PG program (Level 6)** serves as a **foundational stage**, focusing on **core disciplinary knowledge, skill development, and interdisciplinary exposure**. The curriculum comprises:

- **Discipline-Specific Core (DSC) Courses** – Fundamental courses providing in-depth knowledge of the subject.
- **Discipline-Specific Electives (DSE)** – Advanced electives allow students to specialize in emerging areas within their field.
- **Generic Electives (GE)** – Courses from other disciplines that broaden students' perspectives and foster interdisciplinary learning.

This stage ensures students gain a **strong theoretical base** while developing practical expertise through **labs, projects, and industry interactions**.

Level 6.5: Second Year of Two-Year PG / One-Year PG (Three Flexible Options)

The second year of the PG program (Level 6.5) or a one-year PG provides students with three academic pathways, allowing flexibility in their learning trajectories:

1. Coursework-Only Option – Focused on deep theoretical and practical knowledge through advanced courses and professional skill-building.
2. Coursework + Research Option – A blended approach incorporating coursework with a research component, enabling students to undertake short-term research projects along with structured learning.
3. Research-Only Option – Designed for students aiming for higher research, this track allows them to engage in an intensive research thesis, fostering innovation and scholarly contribution in their field.

This framework aligns with NEP 2020's vision of interdisciplinary learning, global competitiveness, and research-driven education, ensuring that PG programs equip students with the necessary expertise, innovation skills, and career readiness for academia, industry, or entrepreneurship.

Admission Requirements
Candidates must fulfill **one** of the following criteria:

I. Bachelor's Degree in Science:

A. Admission to a 2-Year PG Program (After a 3-Year B.Sc. Degree): Candidates who have completed a 3-year B.Sc. degree in the following disciplines are eligible for admission to the 2-year PG program:

- B.Sc. in Computer Science, Physics, Electronics, Mathematics, Statistics, or Operational Research
- B.Sc. (Three-Subject Scheme) in Physics, Mathematics, Electronics, Computer Science, or related disciplines

- B.A.Sc. (Applied Science) in Electronics/Instrumentation from the University of Delhi or an equivalent qualification from a recognized institution

B. Admission to a 1-Year PG Program (After a 4-Year B.Sc. Degree): Candidates who have completed a 4-year B.Sc. degree (as per the National Education Policy) in any of the above-mentioned disciplines are eligible for admission to the 1-year PG program.

Students must have the necessary background in **Mathematics, Physics, or Computer Science**, with at least **2 papers in Mathematics** and **1 paper in Computer Science**.

Minimum Marks Requirement:
A minimum of 50% marks for UR category and as per university norms for reserved categories in the qualifying degree is required.

II. Engineering Degree:

Candidates with a B.E./B.Tech. degree (10+2+4 scheme) in any discipline from the University of Delhi or an equivalent recognized university/institution can apply. A minimum of 50% marks for UR and other reservations as per university norms in the qualifying degree is required .

Admission Procedure
Admission to the program will be based on the candidate's performance in the Common University Entrance Test for Postgraduate (CUET-PG) /as per University norms. Candidates who meet the cutoff criteria set by the university will be shortlisted. Final selection will be based on cutoff and Interview marks.

Assessment & Grading Policy
The grade awarded to a student in any course is based on their performance in the End Semester Examination. The corresponding letter grades and grade points are listed in Table I.

Table 1: Grade points and description of performance

Letter Grade	**Grade Point (GPA/CGPA Scale 10)**	**Performance Description**
O (Outstanding)	10	91-100%
A+ (Excellent)	9	81-90%
A (Very Good)	8	71-80%
B+ (Good)	7	61-70%
B (Above Average)	6	51-60%
C (Average)	5	41-50%
D (Minimum Passing)	4	40%
F (Fail)	0	Below 40%
Ab (Absent)	0	Absent in Exam

For computing the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA), only courses in which the student has secured a grade between *A* and *D* will be considered.

$$GPA = \frac{\Sigma(Number\ of\ Credits \times Grade\ Points)}{\Sigma Number\ of\ Credits}$$

The *F* Grade represents an unsatisfactory performance in a course. A student receiving an F Grade must repeat both theory and practical courses in which they failed.

Guidelines for the Award of 'I' (Incomplete) Grade
The *I* Grade may be awarded to a student who has not met all course requirements due to extraordinary circumstances, provided that:

- The student has attended at least 50% of the laboratory classes.
- The course coordinator is convinced about the circumstances and certifies the attendance record.
- The 'I' Grade must be converted into a proper grade within 10 days from the completion of the End Semester Examination.

Promotion to the Next Semester
A student will be promoted to the next semester only if they meet the following conditions:

1. **Practical Courses:** Must secure at least a 'D' Grade in all practical courses (no practical course can be carried over).
2. **Theory Courses:**
    - For a four-theory semester, the student must secure at least a 'D' Grade in two theory courses.
    - For a five-theory semester, the student must secure at least a 'D' Grade in three theory courses.

Repeating a Course and Additional Fees

- If a student needs to repeat a theory course from any semester, they must pay an additional examination fee for that semester/as per examination/University norms.
- The student must follow the syllabus prescribed for the fresh batch and appear for exams alongside regular students of that semester.

Attendance Requirement

- Attendance in all classes is mandatory.
- A student must maintain a minimum of 75% attendance in each subject to be eligible for the end-semester examination.
- If a student's attendance in any subject falls below 75%, they will not be allowed to appear for the examination in that subject.
- A student with poor attendance (below 75%) may be required to repeat the subject.
- Condonation of up to 25% may be granted on medical grounds or as per University norms, subject to approval.

Assessment of Student Performance and Examination Scheme

Each course carries 10 grade points, and the mode of evaluation is as follows:

For Theory Courses:

- Internal Assessment: 25% weightage
- End Semester Examination: 75% weightage

For Practical Courses:

- Continuous Evaluation during the Semester: 30% weightage
- End Semester Practical Examination/Viva-Voce: 70% weightage

Dissertation Writing Track in the Second Year of PG Programmes:

Semester III
The following four outcomes must be achieved by the end of III Semester:

- Research Problem identification
- Review of literature
- Research design formulation
- Commencement of experimentation, fieldwork, or similar tasks

Semester IV
The following three outcomes must be achieved by the end of IV Semester:

- Completion of experimentation/ fieldwork
- Submission of dissertation
- Research output in the form of any one of the following –
    - Prototype or product development/ patent
    - Any other scholastic work as recommended by the BRS and approved by the Research Council
    - Publication in a reputed Journals such as Scopus indexed journals or other similar quality journals
    - Book or Book Chapter in a publication by a reputed publisher

Academic Projects in the 2nd Year of PG Programmes

Semester III

The following four outcomes must be achieved by the end of III Semester:

- Research Problem identification
- Review of literature
- Research design formulation
- Commencement of experimentation, fieldwork, or similar tasks

Semester IV

The following three outcomes must be achieved by the end of IV Semester:

- Completion of the experimentation, fieldwork or similar task.
- Submission of project report
- Research output in the form of any one of the following –
    - Prototype or product development or patent
    - Any other scholastic work as recommended by the BRS and approved by the Research Council
    - Publication in a reputed Journals such as Scopus indexed journals or other similar quality journals
    - Draft policy formulation and submission to the concerned Ministry
    - Book or Book Chapter in a publication by a reputed publisher
    - Book translation (for Language departments)

Maximum Duration for Completion of the Program

If a student is unable to complete the coursework satisfactorily due to academic performance issues or unavoidable circumstances (such as medical reasons), they may choose to continue their studies by moderating their study plan in the subsequent semesters. To accommodate such cases, students may take a longer duration to fulfill the program requirements. Accordingly, the maximum duration allowed for completing all requirements of the MSc Informatics is 4 years from the date of admission.

Degree Requirements (3+2 scheme)

A degree will be awarded for the Two-year PG Programme (3+2) upon fulfilling the respective academic requirements for each program format:

1. Coursework-Based Program

- 10 Core Courses (Mandatory)
- 10 DSEs, or 06 DSEs+ 04 GEs
- Project Dissertation / Hands-on Training
- A total of 88 credits through successful course completion and assessments

2. Coursework + Research-Based Program

- 10 Core Courses (Mandatory)

- 08 DSEs, or 04 DSEs + 04 GEs
- Research Component:
  - A Research Project/Dissertation equivalent to the credit requirement
  - Submission of a research report/thesis evaluated by faculty
  - Participation in a seminar/presentation on research work
- A total of 88 credits, with coursework and research combined

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3. Research-Based Program

- 07 Core Courses
- 06 DSEs, or 04 DSEs + 02 GEs
- 02 Research Methods/ Tools/ Writing Courses
- Extensive Research Work:
  - Conduct original research under faculty supervision
  - Submission of a Research Thesis/Dissertation
  - Successful completion of research evaluations (seminars, progress reviews)
- A total of 88 credits, primarily research-focused

Degree Requirements (4+1 scheme)

A degree will be awarded for one year PG Programme after completion of the Four-Year UG Programme (4+1) upon fulfilling the respective academic requirements for each program format:

1. Coursework-Based Program

A student must successfully complete the following:

- 04 Core Courses (Mandatory)
- 06 DSEs, or 04 DSEs+ 02 GEs
- Project Dissertation / Hands-on Training
- A total of 44 credits through successful course completion and assessments

2. Coursework + Research-Based Program

- 04 Core Courses (Mandatory)
- 04 DSEs, or 02 DSEs + 02 GEs
- Research Component:
  - A Research Project/Dissertation equivalent to the credit requirement
  - Submission of a research report/thesis evaluated by faculty
  - Participation in a seminar/presentation on research work
- A total of 44 credits, with coursework and research combined

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3. Research-Based Program

- 01 Core Course
- 02 DSEs
- 02 Research Methods/ Tools/ Writing Courses
- Extensive Research Work:
    - Conduct original research under faculty supervision
    - Submission of a Research Thesis/Dissertation
    - Successful completion of research evaluations (seminars, progress reviews)
- A total of 44 credits, primarily research-focused

Revised Structure: Master of Science in Informatics (M.Sc. - Informatics)

M.Sc. Informatics – Two-Year PG Course Credit Scheme (3+2)

Structure-1 (Level 6.5): PG with Only Coursework

Semester	Core Courses		Elective Courses		Skill-based/Hands-on		Research Methods		Dissertation/Project		Total Credits
	No.	Credits	No.	Credits	No.	Credits	No.	Credits	No.	Credits	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	3	12	1	2	-	-	-	-	22
IV	2	8	3	12	1	2	-	-	-	-	22
Total	10	40	10	40	4	8	-	-	-	-	**88**

Structure-2 (Level 6.5): PG with Coursework + Research

Semester	Core Courses		Elective Courses		Skill-based/Hands-on		Research Methods		Dissertation/Project		Total Credits
	No.	Credits	No.	Credits	No.	Credits	No.	Credits	No.	Credits	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	2	8	-	-	-	-	1	6	22
IV	2	8	2	8	-	-	-	-	1	6	22
Total	10	40	8	32	2	4	-	-	2	12	**88**

Structure-3 (Level 6.5): PG with Research

Semester	Core Courses		Elective Courses		Skill-based/Hands-on		Research Methods		Dissertation/Project		Total Credits
	No.	Credits	No.	Credits	No.	Credits	No.	Credits	No.	Credits	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	1	4	1	4	-	-	2	4	1	10	22
IV	-	-	1	4	-	-	1	2	1	16	22
Total	7	28	6	24	2	4	3	6	2	26	**88**

Table - II: List of Discipline Specific Electives	
Code	**Course Name**
ITDSE-01	Principles of Informatics & Digital Transformation
ITDSE-02	Programming Paradigms (C, C++)
ITDSE-03	Programming for Data Science (Python, R)
ITDSE-04	Digital Canvas: An Introduction to UI/UX Design
ITDSE-05	Mathematical foundations of computing
ITDSE-06	Computer organization and systems
ITDSE-07	Cyber Law, Data Protection & Privacy Regulations
ITDSE-08	AI-Driven Web & Mobile Application Development
ITDSE-09	Digital Image Processing
ITDSE-10	Blockchain Development & Smart Contracts
ITDSE-11	Digital electronics and Internet of Things (IoT)
ITDSE-12	Digital Forensics & Cyber Threat Intelligence
ITDSE-13	Explainable AI (XAI) & Model Interpretability
ITDSE-14	Software Engineering & Agile Development
ITDSE-15	Autonomous Systems & Robotics
ITDSE-16	NLP & Speech Processing
ITDSE-17	Deep Learning for Computer Vision
ITDSE-18	Digital Health Informatics
ITDSE-19	Cloud Computing & DevOps
ITDSE-20	Introduction to the Theory of Computation
ITDSE-21	Algorithms and Computation

Table III: List of General Electives	
Code	**Course Name**
ITGE01	Introduction to Computational Thinking & Problem Solving
ITGE02	Digital Humanities & Computational Social Sciences
ITGE03	Ethical AI & Bias Mitigation in Machine Learning
ITGE04	Ethical AI & Responsible Tech Development
ITGE05	Augmented Reality (AR) & Virtual Reality (VR)
ITGE06	Assistive Technologies & Digital Accessibility
ITGE07	Green Computing & Sustainable Technology
ITGE08	Advanced Robotics & Human-AI Collaboration
ITGE09	Social Network Analysis & Computational Propaganda
ITGE10	Cyber-Physical Systems & Smart Infrastructure
ITGE11	Future of Work: AI, Automation & Digital Labor
ITGE12	Introduction to Human-Computer Interaction
ITGE13	Research Methodology & Scientific Writing

Course Credit Scheme	
1st Year of PG for 2-year PG Programmes (3+2)	● Total credits = 44 ● Number of Discipline-Specific Core Papers = 06 ● Project (Dissertation) = Nil ● Number of Discipline-Specific Electives Papers = 04 ● Number of General Elective papers = 02 ● Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning = 01
2nd Year of PG for Two-year PG Programme (3+2) or after completion of Four-Year UG Programme (4+1) with **only coursework**	● Total credits = 44 ● Number of Discipline-Specific Core Papers = 04 ● Project (Dissertation) = Nil ● Number of Discipline-Specific Electives Papers = 06 ● Number of General Elective papers = 02 ● Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning = 01

2nd Year of PG for Two-year PG Programme (3+2) or after completion of Four-Year UG Programme (4+1) with **coursework + research**	● Total credits = 44 ● Number of Discipline-Specific Core Papers = 04 ● Project (Dissertation) = 01 ● Number of Discipline-Specific Electives Papers = 04 ● Number of General Elective papers = 02 ● Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning = Nil
2nd Year of PG for Two-year PG Programme (3+2) or after completion of Four-Year UG Programme (4+1) with **only Research**	● Total credits = 44 ● Number of Discipline-Specific Core Papers = 01 ● Project (Dissertation) = 01 ● Number of Discipline-Specific Electives Papers = 02 ● Number of General Elective papers = Nil ● Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning = Nil ● Research Methods/ Tools/ Writing = 03

Selection of Discipline-Specific Electives and Generic Electives:

The selection of Discipline-Specific Electives and Generic Electives will be carried out through mutual consultation between students and the respective faculty members. However, students will have the flexibility to choose an elective from the available options. The list of Discipline-Specific Electives is provided in Table II, while the list of Generic Electives is provided in Table III.

Instructional Framework and Faculty Involvement:
The faculty of the department is primarily responsible for conducting lectures for courses as outlined in the syllabus. Tutorials are managed by the respective registering units under the overall supervision of the department. Additionally, as needed, faculty members from industry, other departments, and constituent colleges may also be involved in delivering lectures and conducting practical sessions within the department. Each semester will consist of 90 instructional days, excluding examination days.

M.Sc. Informatics - Course Wise Content Details

First Semester

ITC101: Artificial Intelligence: Principles and Techniques
Marks: 100 | Duration: 60 Hrs

Course Objectives:

This course introduces the fundamental principles of Artificial Intelligence. Introduce search algorithms, knowledge representation, machine learning techniques, and AI-driven decision-making.

Course Learning Outcomes (CLOs):

- CLO1: Understand the core principles of AI and its real-world applications.
- CLO2: Learn various search techniques (uninformed, heuristic, adversarial).
- CLO3: Apply knowledge representation and reasoning for problem-solving.
- CLO4: Understand machine learning basics and AI-based decision systems.
- CLO5: Discuss AI's ethical implications and societal impact.

Course Contents:

- UNIT I: Introduction to AI, problem-solving strategies, and heuristic search techniques.
- UNIT II: Knowledge representation, logic-based AI, probabilistic graphical models, and reasoning methods.
- UNIT III: Machine learning techniques: supervised, unsupervised, and reinforcement learning.
- UNIT IV: AI applications in robotics, expert systems, natural language processing (NLP).
- UNIT V: Ethical considerations, explainable AI, AI safety, and industry applications.
- The course includes tutorials/case studies/hands-on/interactive learning exercises to enhance practical understanding and application.

Recommended Readings:

1. Stuart Russell & Peter Norvig, "Artificial Intelligence: A Modern Approach", Pearson, 3rd Edition.
2. Elaine Rich, "Artificial Intelligence", McGraw-Hill.
3. Nils J. Nilsson, "Artificial Intelligence: A New Synthesis", Morgan Kaufmann.

ITC102: Operating Systems
Marks: 100 | Duration: 60 Hrs

Course Objectives:

This course covers operating system principles, including process scheduling, memory management, file systems, distributed systems, and security mechanisms.

Course Learning Outcomes:

- CLO1: Understand the fundamental structure of operating systems.
- CLO2: Learn process scheduling and resource management techniques.
- CLO3: Gain insights into memory management, virtual memory, and paging.
- CLO4: Explore file system architectures and I/O device management.
- CLO5: Study distributed computing, virtualization, and OS security.

Course Contents:

- UNIT I: Introduction to OS, types of OS, system calls, process scheduling.
- UNIT II: Interprocess communication, synchronization, deadlock detection/prevention.
- UNIT III: Memory management (paging, segmentation, virtual memory, MMU).
- UNIT IV: File systems, disk scheduling, security models, and access control policies.
- UNIT V: Virtualization, containerization (Docker, Kubernetes), cloud-based OS, and distributed OS models.
- The course includes tutorials/case studies/hands-on/interactive learning exercises to enhance practical understanding and application.

Recommended Readings:

1. Abraham Silberschatz, "Operating System Concepts", Wiley, 10th Edition.
2. William Stallings, "Operating Systems: Internals and Design Principles", Pearson.
3. Andrew S. Tanenbaum, "Modern Operating Systems", Pearson.

ITC103: Data Science & Big Data Analytics
Marks: 100 | Duration: 60 Hrs

Course Objectives:

This course focuses on data science techniques, statistical modeling, machine learning for big data, and scalable analytics frameworks.

Course Learning Outcomes:

- CLO1: Understand the core concepts of data science and its applications.
- CLO2: Learn data wrangling techniques for structured and unstructured datasets.
- CLO3: Apply statistical and machine learning models to solve real-world problems.
- CLO4: Develop data visualization techniques to communicate insights effectively.

Course Contents:

- UNIT I: Introduction to Data Science, Understanding structured, semi-structured, and unstructured data, Overview of data-driven decision-making and business intelligence.
- UNIT II: Data collection, handling missing values, and cleaning techniques, Feature selection, scaling, encoding, and transformation, Handling categorical and numerical data. Exploratory Data Analysis (EDA) and statistical summary.
- UNIT III: Descriptive statistics: mean, median, mode, variance, and standard deviation, Probability distributions (normal, binomial, Poisson), Hypothesis testing, confidence intervals, and p-values, correlation and regression analysis.
- UNIT IV: Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop**,** Hadoop Distributed File System.
- UNIT V: Importance of data visualization in decision-making, Data visualization tools: Matplotlib, Seaborn, Plotly, Tableau, Time-series visualization and dashboards, Communicating insights through effective reporting.
- The course includes tutorials/case studies/hands-on/interactive learning exercises to enhance practical understanding and application.

Recommended Readings:

1. Joel Grus, "Data Science from Scratch", O'Reilly.
2. Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow", O'Reilly.
3. Tom White, "Hadoop: The Definitive Guide", O'Reilly.
4. Seema Acharya, Subhasini Chellappan, "Big Data Analytics" Wiley 2015.

ITL106: Computational Data Science Lab

Marks: 100 | Duration: 30 Hrs

Course Objectives:

The lab focuses on practical implementation of data science techniques, software programming, and handling real-world datasets for analytics.

Course Learning Outcomes:

- CLO1: Implement Python-based data science workflows.
- CLO2: Use Jupyter, Pandas, NumPy, and SciPy for data analysis.
- CLO3: Work with machine learning models (scikit-learn, TensorFlow, PyTorch).
- CLO4: Implement big data processing in Spark and Hadoop.
- CLO5: Perform data visualization and storytelling (Tableau, Power BI, Matplotlib).

Course Activities:

- Lab 1: Introduction to Python for Data Science.
- Lab 2: Exploratory Data Analysis and Visualization.
- Lab 3: Implementation of Exploratory Data Analysis.

- Lab 4: Big Data Analytics.
- Lab 5: Cloud-based Data Science Solutions.

Recommended Readings:

1. Wes McKinney, "Python for Data Analysis", O'Reilly.
2. Jake VanderPlas, "Python Data Science Handbook", O'Reilly.

Second Semester

ITC201: Advanced Data Structures

Marks: 100 | Duration: 60 Hrs

Course Objectives:

This course provides a comprehensive understanding of data structures, focusing on efficient data organization, manipulation, and retrieval techniques. Students will learn fundamental and advanced data structures, their implementations, and their applications in problem-solving and algorithm development.

Course Learning Outcomes:

- CLO1: Understand the concepts, operations, and importance of data structures in computer science.
- CLO2: Analyze and implement linear data structures such as arrays, linked lists, stacks, and queues.
- CLO3: Apply non-linear data structures like trees and graphs for various applications.
- CLO4: Implement sorting, searching, and hashing algorithms for data optimization.
- CLO5: Evaluate time and space complexities of different data structures and algorithms.

Course Contents:

- UNIT I: Introduction to Data Structures & Algorithm Analysis, Abstract Data Types (ADTs), Recursive Algorithms and Applications
- UNIT II: Linear Data Structures, Arrays: Static and Dynamic Arrays, Multi-dimensional Arrays, Linked Lists: Singly, Doubly, and Circular Linked Lists, Stacks: Implementation using Arrays and Linked Lists, Applications (Expression Evaluation, Backtracking), Queues: Implementation of Circular Queue, Deque, Priority Queue
- UNIT III: Non-Linear Data Structures, Trees: Binary Trees, Binary Search Trees (BST), AVL Trees, Heap Trees, B-Trees, Graph Theory: Representation (Adjacency Matrix & List), BFS, DFS, Graph Algorithms: Dijkstra's Shortest Path, Floyd-Warshall, Kruskal's and Prim's Algorithm
- UNIT IV: Sorting Algorithms: Bubble Sort, Selection Sort, Merge Sort, Quick Sort, Heap Sort, Searching Algorithms: Linear Search, Binary Search, Hashing: Hash Functions, Collision Resolution Techniques (Chaining, Open Addressing)
- UNIT V: Advanced Data Structures & Applications, Prefix Trees, Suffix Trees, Tries, Applications in Databases, AI, and Web Technologies
- The course includes tutorials/case studies/hands-on/interactive learning exercises to enhance practical understanding and application.

Recommended Readings:

1. Data Structures and Algorithm Analysis in C – Mark Allen Weiss, Pearson.
2. Data Structures and Algorithms Made Easy – Narasimha Karumanchi, CareerMonk Publications.
3. Introduction to Algorithms – Cormen, Leiserson, Rivest, and Stein (CLRS), MIT Press.

4. Data Structures and Algorithms in Java – Robert Lafore, Pearson.
5. The Algorithm Design Manual – Steven S. Skiena, Springer.

ITC202: Computer Networks and Communication

Marks: 100 | Duration: 60 Hrs

Course Objectives:

This course provides a comprehensive understanding of computer networks, communication protocols, and network security. It covers network architectures, data transmission techniques, networking models, and emerging network technologies such as 5G, SDN, and IoT.

Course Learning Outcomes:

- CLO1: Understand fundamental networking concepts, architectures, and protocols.
- CLO2: Learn the OSI and TCP/IP models and how data transmission occurs across networks.
- CLO3: Gain knowledge of wired and wireless networking technologies.
- CLO4: Understand network security principles and how to protect networked systems.
- CLO5: Explore advanced networking technologies like Software-Defined Networking (SDN), Cloud Networking, and IoT communication.

Course Contents:

- UNIT I: Introduction to Computer Networks, Overview of Networking and Communication, Types of Networks: LAN, WAN, MAN, PAN, Network Models: OSI Model, TCP/IP Model, Data Transmission Techniques: Serial vs Parallel, Synchronous vs Asynchronous
- UNIT II: Network Protocols and Layered Architecture, Physical Layer: Data Encoding, Modulation, Multiplexing, Data Link Layer: Error Detection & Correction, MAC Protocols (CSMA/CD, CSMA/CA), Ethernet, Network Layer: IP Addressing, Subnetting, Routing Algorithms (Distance Vector, Link-State), Transport Layer: TCP vs UDP, Flow Control, Congestion Control
- UNIT III: Wireless and Mobile Networking, Wireless Technologies: Wi-Fi, Bluetooth, RFID, NFC, Cellular Networks: 4G LTE, 5G, Mobile IP, IoT and Edge Computing Communication, Cloud Networking and SDN
- UNIT IV: Emerging Trends and Network Applications, Future of Networking: AI in Networking, Quantum Networks, Network Simulation and Performance Evaluation, Software-Defined Networking (SDN) and Network Function Virtualization (NFV)
- Hands-on with Tools: Wireshark, Cisco Packet Tracer, Mininet

Recommended Readings:

1. Computer Networking: A Top-Down Approach – Kurose & Ross, Pearson.
2. Data and Computer Communications – William Stallings, Pearson.
3. Computer Networks – Andrew S. Tanenbaum, Pearson.
4. TCP/IP Protocol Suite – Behrouz A. Forouzan, McGraw-Hill.
5. Network Security Essentials – William Stallings, Pearson.

ITC203: Database Management & NoSQL Technologies

Marks: 100 | Duration: 60 Hrs

Course Objectives:

This course provides a comprehensive understanding of database management systems (DBMS), relational database design, and an introduction to NoSQL technologies. It covers data modeling, query optimization, transaction management, and scalability in modern database applications. Students will also explore emerging NoSQL paradigms for handling big data and real-time applications.

Course Learning Outcomes:

- CLO1: Understand fundamental database concepts, architectures, and storage mechanisms.
- CLO2: Learn Relational Database Management Systems (RDBMS) and the SQL language for data manipulation.
- CLO3: Design efficient data models, schemas, and normalization techniques.
- CLO4: Gain insights into transaction management, concurrency control, and database security.
- CLO5: Explore NoSQL databases (Key-Value, Document, Columnar, and Graph DBs) and their applications in big data and distributed computing.

Course Contents:

- UNIT I: Introduction to Database Systems, Overview of Database Architectures, Types of Databases: Relational, Hierarchical, Object-Oriented, and NoSQL, Data Independence and Data Models (Conceptual, Logical, Physical), Entity-Relationship (ER) Modeling and Relational Model
- UNIT II: SQL and RDBMS, SQL Queries: DDL, DML, DCL, and TCL, Constraints, Views, Joins, Triggers, and Stored Procedures, Normalization (1NF, 2NF, 3NF, BCNF, 4NF, 5NF), Indexing and Query Optimization
- UNIT III: Transaction Management and Database Security, ACID Properties and Concurrency Control, Deadlock Detection and Prevention, Backup and Recovery Mechanisms, Role-Based Access Control (RBAC) and Database Security Models
- UNIT IV: Introduction to NoSQL Databases, Differences between RDBMS and NoSQL, Types of NoSQL Databases: Key-Value Stores, Document Stores, Columnar Stores, Graph Databases, CAP Theorem and BASE vs ACID Properties
- UNIT V: NoSQL Applications and Big Data Integration, Scalability and Distributed Databases, NoSQL Data Modeling Techniques, Querying NoSQL Databases using MongoDB, Integration of NoSQL with Big Data Technologies.
- The course includes tutorials/case studies/hands-on/interactive learning exercises to enhance practical understanding and application.

Recommended Readings:

1. Database System Concepts – Abraham Silberschatz, Henry Korth, and S. Sudarshan, McGraw-Hill.

2. Fundamentals of Database Systems – Ramez Elmasri and Shamkant B. Navathe, Pearson.
3. SQL: The Complete Reference – James Groff and Paul Weinberg, McGraw-Hill.
4. NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence – Pramod J. Sadalage and Martin Fowler, Addison-Wesley.
5. MongoDB: The Definitive Guide – Kristina Chodorow, O'Reilly.

ITL206: Data Management & Optimization Lab

Marks: 100 | Duration: 60 Hrs

Course Objectives:

This lab focuses on practical implementation of data management techniques, database optimization strategies, and handling large-scale structured and unstructured datasets. Students will gain hands-on experience in SQL and NoSQL database performance tuning, indexing, query optimization, and data processing techniques for big data environments.

Course Learning Outcomes:

- CLO1: Implement database management techniques for handling structured and unstructured data.
- CLO2: Apply SQL and NoSQL query optimization techniques to improve database performance.
- CLO3: Work with data indexing, partitioning, and sharding for large-scale databases.
- CLO4: Use ETL (Extract, Transform, Load) pipelines for efficient data processing.
- CLO5: Optimize data storage and retrieval techniques using advanced tools.

Tools & Technologies Used:

- Relational Databases: MySQL, PostgreSQL, SQLite
- NoSQL Databases: MongoDB, Cassandra
- Big Data Frameworks: Apache Hadoop, Apache Spark
- Performance Monitoring Tools: MySQL Workbench, pgAdmin, MongoDB Atlas

Recommended Readings:

1. Database System Concepts – Abraham Silberschatz, Henry Korth, and S. Sudarshan, McGraw-Hill.
2. SQL Performance Explained – Markus Winand, Redgate.
3. High-Performance MySQL – Baron Schwartz, O'Reilly.
4. MongoDB Performance Tuning – Guy Harrison, O'Reilly.
5. Optimizing SQL Queries for Faster Execution – Ian Robinson, Packt.

Third Semester

ITC301: Cybersecurity Risk Management & Compliance

Marks: 100 | Duration: 60 Hrs

Course Objectives:

This course provides a comprehensive understanding of cybersecurity risk management, governance frameworks, and compliance regulations. Students will learn to identify, assess, and mitigate security risks, ensuring organizations meet industry security standards and regulatory requirements. The course also covers cyber risk assessment methodologies, security policies, compliance laws (GDPR, ISO 27001, NIST, etc.), and cybersecurity frameworks for effective risk management.

Course Learning Outcomes:

- CLO1: Understand cybersecurity risk management principles, strategies, and threat mitigation techniques.
- CLO2: Learn industry-recognized security frameworks and compliance regulations.
- CLO3: Conduct cyber risk assessments and vulnerability analysis using modern tools and methodologies.
- CLO4: Develop and implement security policies, incident response plans, and disaster recovery strategies.
- CLO5: Analyze real-world case studies of cybersecurity breaches and regulatory non-compliance.

Course Contents:

- UNIT I: Introduction to Cybersecurity Risk Management, Fundamentals of Risk, Threats, and Vulnerabilities, Types of Cybersecurity Risks (Data Breaches, Insider Threats, Ransomware, Zero-Day Exploits), Risk Management Lifecycle: Identification, Assessment, Mitigation, Monitoring, Cyber Risk Quantification Techniques
- UNIT II: Cybersecurity Compliance and Regulatory Standards, Overview of Information Security Compliance, ISO 27001: Information Security Management System (ISMS), GDPR (General Data Protection Regulation) and Data Privacy Laws, NIST Cybersecurity Framework (Identify, Protect, Detect, Respond, Recover), SOC 2, HIPAA, PCI-DSS: Industry-Specific Compliance
- UNIT III: Risk Assessment, Governance, and Security Policies, Cyber Risk Assessment Methodologies (Qualitative vs Quantitative Risk Analysis), Network Security and Cryptography, Encryption Techniques: Symmetric (AES, DES), Asymmetric (RSA, ECC), Firewall, IDS, IPS, VPN, and Network Access Control (NAC), Secure Communication Protocols: SSL/TLS, IPSec, HTTPS
- UNIT IV: Threat Intelligence, Incident Handling, and Digital Forensics, Intrusion Detection and Prevention Systems (IDS/IPS), Incident Response Frameworks (SANS, NIST Incident Handling Guide), Digital Forensics & Evidence Handling
- UNIT V: Emerging Trends in Cyber Risk and Compliance, Cloud Security and Compliance Challenges, Zero Trust Security Model, AI & Machine Learning in Cybersecurity Risk Analysis, Future of Cybersecurity Regulation and Policy

- The course includes tutorials/case studies/hands-on/interactive learning exercises to enhance practical understanding and application.

Recommended Readings:

1. Cybersecurity and Cyber Risk Management – David Sutton, BCS Learning & Development.
2. Information Security Risk Management for ISO 27001/ISO 27002 – Alan Calder, IT Governance Publishing.
3. Cybersecurity Risk Management: Mastering the Fundamentals – Evan Wheeler, Elsevier.
4. GDPR Compliance and Data Protection – Ardi Kolah, Kogan Page.
5. The NIST Cybersecurity Framework: A Comprehensive Guide – Alan Friedman, Wiley.

ITC302: Advanced Topics in Machine Learning and AI

Marks: 100 | Duration: 60 Hrs

Course Objectives:

This course provides an in-depth understanding of advanced machine learning techniques and artificial intelligence methodologies. It covers deep learning architectures, generative AI models, reinforcement learning, explainable AI (XAI), and federated learning. Students will explore cutting-edge AI research trends, optimization strategies, and applications in real-world scenarios such as healthcare, finance, and autonomous systems.

Course Learning Outcomes:

- CLO1: Understand advanced machine learning algorithms and deep learning architectures.
- CLO2: Explore reinforcement learning models and decision-making AI systems.
- CLO3: Learn about trustworthy AI applications.
- CLO4: Gain expertise in generative models such as GANs, VAEs, and transformers.
- CLO5: Analyze real-world AI applications and emerging AI trends (federated learning, edge AI, quantum AI).

Course Contents:

- UNIT I: Machine Learning Fundamentals, Supervised and unsupervised learning, Overview of classification (Logistic Regression, Decision Trees, k-NN), Ensemble Learning: Boosting (AdaBoost, Gradient Boosting, XGBoost), Bagging, Evaluation metrics (precision, recall, F1-score, confusion matrix).
- UNIT II: Clustering techniques (K-Means, Hierarchical, DBSCAN), Anomaly Detection & Outlier Analysis, Unsupervised Learning: Autoencoders, Dimensionality Reduction Techniques: PCA, t-SNE, UMAP
- UNIT III: Deep Learning Architectures, Convolutional Neural Networks (CNNs): ResNet, DenseNet, EfficientNet, Recurrent Neural Networks (RNNs) and LSTMs, Optimization Techniques: Adam, RMSprop, L-BFGS, Dropout, Batch Normalization.

- UNIT IV: Reinforcement Learning (RL) and Decision-Making AI, Introduction of Semi-Supervised and Reinforcement Learning, Markov Decision Processes (MDPs) and Q-Learning, Applications of RL: Robotics, Game AI, Finance
- UNIT V: Introduction of XAI, Emerging Trends in AI, Introduction to Federated Learning and Privacy-Preserving AI, Introduction to Edge AI and AI in IoT Systems, Introduction to Quantum Machine Learning, Introduction to Autonomous AI Systems (Self-Driving Cars, AI in Healthcare, Smart Cities).
- The course incorporates tutorials/case studies/hands-on exercises/interactive learning methods to enhance practical understanding and application.

Recommended Readings:

1. Deep Learning – Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press.
2. Reinforcement Learning: An Introduction – Richard S. Sutton, Andrew G. Barto, MIT Press.
3. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow – Aurélien Géron, O'Reilly.
4. Interpretable Machine Learning – Christoph Molnar, Leanpub.
5. AI Ethics – Mark Coeckelbergh, MIT Press.

ITL306: Machine Learning & Data Analytics Lab

Marks: 100 | Duration: 30Hrs

Course Objectives:

This lab provides hands-on experience in implementing machine learning models, data preprocessing techniques, feature engineering, and advanced analytics. Students will work with real-world datasets, apply deep learning algorithms, and perform predictive modeling cloud-based ML platforms.

Course Learning Outcomes:

- CLO1: Implement machine learning algorithms for supervised and unsupervised learning tasks.
- CLO2: Perform data preprocessing, feature selection, and dimensionality reduction.
- CLO3: Work with deep learning models (CNNs, RNNs, Transformers) and optimization techniques.
- CLO4: Apply big data analytics techniques using Apache Spark and cloud-based ML platforms.
- CLO5: Conduct model evaluation, tuning, and interpretability analysis using XAI.

Course Activities:

- Module 1: Data Preprocessing & Feature Engineering
- Module 2: Supervised and Unsupervised Machine Learning
- Module 3: Deep Learning & Neural Networks
- Module 4: Model Evaluation & Explainability

Tools & Technologies Used:

- Programming Languages: Python (Scikit-learn, TensorFlow, PyTorch), R
- Big Data Frameworks: Apache Spark MLlib, Hadoop
- Cloud AI Tools: AWS SageMaker, Google Vertex AI
- Visualization & Model Interpretation: Seaborn, Matplotlib, SHAP, LIME

Recommended Readings:

1. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow – Aurélien Géron, O’Reilly.
2. Pattern Recognition and Machine Learning – Christopher M. Bishop, Springer.
3. Deep Learning for Computer Vision – Rajalingappaa Shanmugamani, Packt.
4. Mastering Apache Spark 3 – Mike Frampton, Packt.
5. Interpretable Machine Learning – Christoph Molnar, Leanpub.

Fourth Semester

ITC401: Information System Design and Management

Marks: 100 | Duration: 60 Hrs

Course Objectives:

This course focuses on the principles, methodologies, and best practices of software engineering and information system design. It covers software development life cycle (SDLC), system modeling, software architecture, project management, and quality assurance. The course also emphasizes agile methodologies, DevOps practices, and modern software engineering tools for managing large-scale software systems.

Course Learning Outcomes:

- CLO1: Understand the fundamental concepts of software engineering and information systems.
- CLO2: Learn different Software Development Life Cycle (SDLC) models and system design approaches.
- CLO3: Apply software modeling techniques (UML, ER Diagrams, DFDs) for system analysis and design.
- CLO4: Gain knowledge of software architecture, design patterns, and best practices.
- CLO5: Implement software project management strategies including Agile, Scrum, and DevOps.
- CLO6: Understand software testing, validation, and quality assurance methods for building robust systems.

Course Contents:

- UNIT I: Information Systems in Business and Strategy, Role of Information Systems in Organizations and Global Business, E-Business and Digital Collaboration, Information Systems and Business Strategy, Ethical and Social Issues in Information Systems
- UNIT II: IT Infrastructure and Emerging Technologies, IT Infrastructure Components and Cloud Computing, Foundations of Business Intelligence: Databases and Information Management, Telecommunications, Internet, and Wireless Technologies
- UNIT III: Cybersecurity and Risk Management, Cybersecurity: Securing Information Systems, IT Governance and Regulatory Compliance, Risk Management and Disaster Recovery Planning, Cyber Threat Mitigation
- UNIT IV: Enterprise Applications and E-Commerce, Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and Supply Chain Management (SCM), E-Commerce Models: Digital Markets and Digital Goods, Managing Knowledge and Enhancing Decision Making, Business Intelligence and Big Data Analytics
- UNIT V: Building and Managing Information Systems, Systems Development Life Cycle (SDLC) and Agile Development, Information System Project Management, Managing IT in Global Organizations, Emerging Trends in Digital Transformation Information System Project Management, Managing IT in Global Organizations, IT Governance and Regulatory Compliance

- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Management Information Systems: Managing the Digital Firm – Kenneth C. Laudon, Jane P. Laudon, Pearson.
2.
3. Enterprise Architecture as Strategy – Jeanne W. Ross, Peter Weill, David C. Robertson, Harvard Business Review Press.
4.
5. Information Systems: A Manager's Guide to Harnessing Technology – John Gallaugher, Flat World Knowledge.
6.
7. IT Governance: How Top Performers Manage IT Decision Rights for Superior Results – Peter Weill, Jeanne W. Ross, Harvard Business Press.

ITC402: Quantum Computing Fundamentals
Marks: 100 | Duration: 60 Hrs

Course Objectives:

This course provides an introduction to quantum computing principles, quantum mechanics, and quantum algorithms. It covers quantum gates, quantum circuits, quantum cryptography, and quantum machine learning. The course also explores the potential applications of quantum computing in cryptography, optimization, artificial intelligence, and complex problem-solving.

Course Learning Outcomes:

- CLO1: Understand the fundamental principles of quantum mechanics and their application to computing.
- CLO2: Learn quantum bit (qubit) representation, quantum gates, and quantum circuits.
- CLO3: Explore quantum algorithms (Shor's algorithm, Grover's search algorithm) and their advantages over classical algorithms.
- CLO4: Gain insights into quantum cryptography, quantum error correction, and quantum supremacy.
- CLO5: Analyze the emerging applications of quantum computing in AI, finance, drug discovery, and optimization problems.

Course Contents:

- UNIT I: Introduction to Quantum Computing and Quantum Mechanics, Overview of Classical vs Quantum Computing, Postulates of Quantum Mechanics (Superposition, Entanglement, Measurement), Qubits and Quantum States (Bloch Sphere Representation), Quantum Operators and Quantum Gates (Pauli, Hadamard, CNOT, Toffoli, Swap)
- UNIT II: Quantum Circuits and Quantum Algorithms, Quantum Circuit Model and Quantum Logic Gates, Quantum Parallelism and Quantum Measurement, Shor's

Algorithm for Integer Factorization (Breaking RSA Cryptography), Grover's Algorithm for Unstructured Search
- UNIT III: Quantum Information, Quantum Key Distribution (QKD) (BB84 Protocol), Quantum Entanglement and Teleportation, Quantum Error Correction Codes (Shor Code, Surface Code), Cryptography, Challenges in Quantum Cryptography
- UNIT IV: Quantum Hardware and Computing Platforms, Quantum Cloud Platforms (IBM Quantum Experience Qiskit, Google Sycamore, D-Wave), Scalability and Noise Challenges in Quantum Computing, Current and Future Quantum Processors
- UNIT V: Emerging Applications of Quantum Computing, Quantum Machine Learning (QML) and Variational Quantum Algorithms, Quantum Computing in AI
- The course incorporates tutorials/case studies/hands-on exercises/interactive learning methods to enhance practical understanding and application.

Recommended Readings:

1. Quantum Computation and Quantum Information – Michael A. Nielsen & Isaac L. Chuang, Cambridge University Press.
2. Quantum Computing: A Gentle Introduction – Eleanor Rieffel & Wolfgang Polak, MIT Press.
3. Quantum Algorithms via Linear Algebra – Richard J. Lipton & Kenneth W. Regan, MIT Press.
4. Quantum Computing for Computer Scientists – Noson S. Yanofsky & Mirco A. Mannucci, Cambridge University Press.
5. Quantum Machine Learning: What Quantum Computing Means to Data Mining – Peter Wittek, Elsevier.

ITL406: Web Applications & Services Lab

Marks: 100 | Duration: 30 Hrs

Course Objectives:

This lab provides hands-on experience in designing, developing, and deploying web applications and services. Students will work with front-end, back-end, and full-stack development frameworks, build RESTful APIs, microservices, and cloud-integrated web applications, and learn modern DevOps practices for scalable deployment.

Course Learning Outcomes:

- CLO1: Develop responsive web applications using HTML, CSS, JavaScript, and modern frameworks.
- CLO2: Implement backend development using Python (Django/Flask) or Node.js (Express.js).
- CLO3: Design and integrate RESTful and GraphQL APIs for web applications.
- CLO4: Work with databases (SQL or NoSQL) for dynamic web applications.
- CLO5: Deploy and manage web applications on cloud platforms (AWS, Azure, GCP, Firebase).

- CLO6: Understand security best practices for web applications (OWASP guidelines, authentication, and authorization).

Course Activities:
Module 1: Front-End Web Development
Module 2: Backend Development & Database Integration
Module 3: Web Services and APIs
Module 4: DevOps & Deployment
Module 5: Advanced Topics & Security

Tools & Technologies Used:

- Front-End: HTML5, CSS3, JavaScript, React.js, Angular, Vue.js
- Back-End: Node.js (Express.js), Python (Django, Flask), FastAPI
- Databases: MySQL, PostgreSQL, MongoDB, Firebase
- APIs: RESTful, GraphQL
- DevOps & Deployment: Docker, Kubernetes, AWS, Azure, Firebase Hosting
- Security: OWASP Top 10, OAuth2, JWT, CSRF Protection

Recommended Readings:

1. Eloquent JavaScript – Marijn Haverbeke, No Starch Press.
2. You Don't Know JS – Kyle Simpson, O'Reilly.
3. Flask Web Development – Miguel Grinberg, O'Reilly.
4. Node.js Design Patterns – Mario Casciaro, Packt.
5. Web Security for Developers – Malcolm McDonald, No Starch Press.

ITDSE-01: Principles of Informatics & Digital Transformation
Marks: 100 | Duration: 60 Hrs

Course Objectives:

1. Introduce fundamental concepts of informatics and its role in the digital era.
2. Explore the impact of digital transformation on industries and organizations.
3. Understand data-driven decision-making and emerging technologies.
4. Discuss ethical, legal, and societal aspects of digital transformation.

Course Learning Outcomes:

1. Understand key informatics concepts and digital transformation principles.
2. Analyze the role of digital technologies in modern enterprises.
3. Apply informatics methods to solve real-world problems.
4. Evaluate ethical and legal challenges in digitalization.

Course Contents:

- UNIT I: Fundamentals of Informatics, Definition, scope, and interdisciplinary nature of informatics, Evolution and significance of informatics in various domains, Role of informatics in scientific research, healthcare, business, and education
- UNIT II: Digital Transformation & Emerging Technologies, Digital transformation: definition, key drivers, and impact on industries, Role of cloud computing in digital transformation, Internet of Things (IoT): architecture, communication models, and applications, Case studies of digital transformation in healthcare, finance, and manufacturing
- UNIT III: Big Data, Analytics & Decision Making, Overview of big data: data sources, structured vs. unstructured data, Data collection, storage, and processing techniques, Data visualization tools and techniques for decision-making, Predictive analytics and AI-driven insights for business intelligence
- UNIT IV: AI, Automation & Cybersecurity, Role of artificial intelligence and automation in modern computing, Applications of AI in business, healthcare, and governance, Cybersecurity challenges in the digital age: threats, risks, and mitigation strategies, Privacy concerns and frameworks for securing personal and organizational data
- UNIT V: Ethical & Legal Aspects of Informatics, Ethical challenges in informatics: bias in AI, digital rights, and misinformation, Global data protection regulations (GDPR, CCPA) and their implications, AI ethics, accountability, and transparency in automated decision-making, Future trends and responsible innovation in informatics
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Laudon & Laudon, *Management Information Systems*.
2. McAfee & Brynjolfsson, *Machine, Platform, Crowd*.
3. Porter & Heppelmann, *How Smart, Connected Products Are Transforming Companies*.
4. Articles and case studies from IEEE, ACM, and Harvard Business Review.

ITDSE-02: Programming Paradigms (C, C++)
Marks: 100 | Duration: 60 Hrs

Course Objectives:

1. Introduce fundamental programming paradigms with C and C++.
2. Develop problem-solving skills through structured and object-oriented programming.
3. Understand memory management, data structures, and algorithms.
4. Prepare students for system programming and software development.

Course Learning Outcomes:

1. Implement structured programming concepts using C.
2. Develop object-oriented solutions using C++.
3. Utilize efficient data structures and algorithms.
4. Optimize memory usage and system resources in programming.

Course Contents:

- UNIT I: Introduction to Programming Paradigms and C Basics, Overview of programming paradigms: Imperative, Procedural, Object-Oriented. Basics of C programming: Variables, data types, operators, and expressions, Control structures: Loops and decision-making statements, Functions and modular programming in C
- UNIT II: Pointers, Memory Management, Understanding pointers and dynamic memory allocation (malloc, calloc, free), Arrays and pointer arithmetic, Linked lists, stacks, and queues, File handling in C
- UNIT III: Introduction to Object-Oriented Programming, Basics of C++: Syntax, classes, and objects, Constructors and destructors, Inheritance: Single, multiple, and hierarchical inheritance, Polymorphism: Function overloading and operator overloading
- UNIT IV: Standard Template Library (STL) and Advanced C++ Concepts, Overview of STL: Vectors, lists, maps, and iterators, Function templates and class templates, Exception handling in C++
- UNIT V: Advanced Programming and System-Level Features, Memory management techniques in C++ (new, delete, smart pointers), Multi-threading concepts (basics of thread creation and synchronization), Performance optimization techniques
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Kernighan & Ritchie, *The C Programming Language*.

2. Stroustrup, *The C++ Programming Language*.
3. Deitel & Deitel, *C++ How to Program*.
4. Robert Lafore, *Object-Oriented Programming in C++*.

ITDSE-03: Programming for Data Science (Python, R)
Marks: 100 | Duration: 60 Hrs

Course Objectives:

1. Introduce Python and R for data science applications.
2. Develop skills for data manipulation, visualization, and statistical analysis.
3. Apply machine learning techniques using Python and R libraries.
4. Prepare students for data-driven decision-making in real-world applications.

Course Learning Outcomes:

1. Implement data handling and processing techniques using Python and R.
2. Perform exploratory data analysis and visualization.
3. Apply machine learning models for classification and regression tasks.
4. Utilize Python and R for real-world data science applications.

Course Contents:

- UNIT I:Overview of Python or R, Setting up Jupyter Notebook, RStudio, and IDEs, Variables, data types, and control structures, Functions and scripting in Python and R
- UNIT II: Data Manipulation and Handling, Working with structured and unstructured data, Data manipulation using Pandas, NumPy (Python) or dplyr, tidyr (R), Handling missing data, filtering, grouping, and summarizing, String operations and regular expressions
- UNIT III: Data Visualization and Statistical Analysis, Data visualization using Matplotlib, Seaborn (Python) and ggplot2 (R), Descriptive statistics and exploratory data analysis (EDA), Probability distributions, hypothesis testing, and regression analysis, Correlation and statistical inference
- UNIT IV: Machine Learning Fundamentals in Python or R, Introduction to machine learning concepts, Supervised learning: Linear Regression, Decision Trees, SVM, Unsupervised learning: K-Means, PCA, Clustering techniques, Implementation using Scikit-learn (Python) and caret (R)
- UNIT V: Working with Databases and Real-World Applications, SQL and NoSQL database integration with Python and R, Web scraping and data acquisition from APIs
- The course incorporates tutorials/case studies/hands-on exercises/interactive learning methods to enhance practical understanding and application.

Recommended Readings:

1. Wes McKinney, *Python for Data Analysis*.
2. Hadley Wickham & Garrett Grolemund, *R for Data Science*.

3. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*.
4. Trevor Hastie, Robert Tibshirani, *The Elements of Statistical Learning*.

ITDSE-04: Digital Canvas: An Introduction to UI/UX Design
Marks: 100 | Duration: 60 Hrs

Course Objectives

- To introduce fundamental principles of User Interface (UI) and User Experience (UX) design.
- To develop an understanding of user-centered design methodologies.
- To provide hands-on experience with wireframing, prototyping, and usability testing.
- To explore modern tools and techniques used in UI/UX design.

Course Learning Outcomes:

1. Explain key UI/UX principles and design methodologies.
2. Conduct user research and usability testing.
3. Develop wireframes, prototypes, and interactive designs.
4. Apply cognitive psychology and accessibility considerations in UI/UX.
5. Utilize modern UI/UX tools like Figma, Adobe XD, or Sketch.

Course Contents

- UNIT I: Introduction to UI/UX Design & User-Centered Design, Definition and importance of UI/UX design, Difference between UI and UX, Principles of user-centered design, Overview of the design thinking process
- UNIT II: User Research & Analysis, Understanding user personas and their importance, Conducting user research: Surveys, interviews, and observations, Analyzing user behavior and journey mapping, Competitive analysis in UI/UX design
- UNIT III: Wireframing & Prototyping, Introduction to wireframes: Low-fidelity vs. high-fidelity wireframes, Prototyping tools and techniques (Figma, Adobe XD, Sketch), Creating interactive prototypes, Usability testing methods: A/B testing and heuristic evaluation
- UNIT IV: Visual & Interaction Design, Fundamentals of color theory, typography, and layout design, Design patterns, consistency, and usability principles, Responsive vs. adaptive design approaches, Microinteractions and animations in UI design
- UNIT V: Usability Testing & Accessibility, UX heuristics and cognitive load reduction techniques, Accessibility guidelines (WCAG compliance), Usability testing strategies and user feedback analysis, Iterative design improvements based on testing outcomes
- The course incorporates tutorials/case studies/hands-on exercises/interactive learning methods to enhance practical understanding and application.

Recommended Readings

1. Norman, D. A. *The Design of Everyday Things*. Basic Books.

2. Krug, S. *Don't Make Me Think: A Common Sense Approach to Web Usability*. New Riders.
3. Garrett, J. J. *The Elements of User Experience*. New Riders.
4. Interaction Design Foundation articles and research papers.

ITDSE-05: Mathematical Foundations of Computing
Marks: 100 | Duration: 60 Hrs

Course Objectives

- To introduce mathematical concepts fundamental to computing and algorithm design.
- To develop logical reasoning and problem-solving skills for computer science applications.
- To provide a foundation in discrete mathematics, probability, and graph theory.
- To explore mathematical modeling techniques used in machine learning and AI.

Course Learning Outcomes (CLOs)

1. Apply set theory, logic, and proof techniques in computing problems.
2. Understand graph theory, combinatorics, and probability in algorithm design.
3. Analyze and solve computational problems using mathematical models.
4. Use linear algebra and matrix operations in applications like data science.

Course Contents

- UNIT I: Set Theory & Combinatorics, Relations, functions, and their properties, Cardinality of sets and countability, Permutations, combinations, and the binomial theorem, Inclusion-exclusion principle and pigeonhole principle
- UNIT II: Graph Theory & Applications, Graph representation: Adjacency matrix and adjacency list, Graph traversals: BFS and DFS, Trees, spanning trees, and minimum spanning tree algorithms, Connectivity, network flows, and applications in computing
- UNIT III: Probability & Statistics, Bayes' theorem and conditional probability, Random variables and probability distributions, Expectation, variance, and standard deviation, Regression and correlation techniques in data analysis
- UNIT IV: Linear Algebra for Computing, Matrices, determinants, and their properties, Vector spaces and linear transformations, Eigenvalues, eigenvectors, and diagonalization, Singular Value Decomposition (SVD) and applications
- UNIT V: Applications in Computing & Machine Learning, Graph theory in social networks and web analytics, Probability and statistics in data science, Linear algebra in graphics and image processing, Applications of eigenvalues and eigenvectors in machine learning
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings

1. Rosen, K. H. *Discrete Mathematics and Its Applications*. McGraw-Hill.
2. Cormen, T. H., Leiserson, C. E., Rivest, R. L. *Introduction to Algorithms*. MIT Press.
3. Grimaldi, R. P. *Discrete and Combinatorial Mathematics*. Pearson.
4. Strang, G. *Linear Algebra and Its Applications*. Brooks Cole.

ITDSE-06: Computer Organization and Systems
Marks: 100 | Duration: 60 Hrs

Course Objectives

- To introduce fundamental principles of computer architecture and system organization.
- To explore hardware-software interactions and system performance considerations.
- To analyze the structure of processors, memory, and input/output systems.
- To provide insights into parallel computing and modern computing architectures.

Course Learning Outcomes:

1. Understand the workings of digital logic circuits and computer organization.
2. Describe instruction set architectures (ISA) and assembly language programming.
3. Analyze memory hierarchy, caching, and performance optimization techniques.
4. Explore modern processor designs, parallel computing, and cloud computing infrastructures.

Course Contents

- UNIT I: Digital Logic & Computer Organization, Boolean algebra, logic gates, and combinational circuits, Sequential circuits: Flip-flops, registers, and counters, Number systems, arithmetic operations, and ALU design, Introduction to computer organization and Von Neumann architecture
- UNIT II: Instruction Set Architecture (ISA) & Assembly Language, Machine instructions, addressing modes, and instruction formats, Assembly language programming and instruction execution cycle, RISC vs. CISC architectures, Control unit design: Hardwired and microprogrammed control
- UNIT III: Memory Hierarchy & Performance Optimization, Memory organization and types: RAM, ROM, cache memory, Cache mapping techniques and replacement policies, Virtual memory, paging, and segmentation, Performance optimization techniques: Pipelining and instruction-level parallelism
- UNIT IV: Modern Processor Architectures & Parallel Computing, Multi-core and superscalar architectures, Thread-level parallelism and GPU computing, Instruction scheduling, out-of-order execution, and branch prediction, Introduction to vector processing and SIMD architectures
- UNIT V: Advanced Computing & Cloud Infrastructures, Introduction to distributed computing and cloud architectures, Virtualization techniques and containerization (Docker, Kubernetes), High-performance computing (HPC) and data centers, Trends in computing: Edge computing, IoT, and AI-driven hardware
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings

1. Stallings, W. *Computer Organization and Architecture: Designing for Performance*. Pearson.
2. Patterson, D. A., Hennessy, J. L. *Computer Organization and Design: The Hardware/Software Interface*. Morgan Kaufmann.
3. Tanenbaum, A. S., Austin, T. *Structured Computer Organization*. Pearson.
4. Mano, M. M., Kime, C. R. *Logic and Computer Design Fundamentals*. Pearson.

ITDSE-07: Cyber Law, Data Protection & Privacy Regulations
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To understand legal frameworks for cybersecurity and data protection.
- To explore privacy regulations across different jurisdictions.
- To analyze case studies on cybercrime, intellectual property, and compliance issues.

Course Learning Outcomes:

1. Explain cyber laws and compliance requirements.
2. Analyze case laws on cybersecurity breaches and data protection.
3. Assess the impact of global privacy regulations like GDPR and CCPA.
4. Develop strategies for ethical and legal data handling.

Course Contents:

- UNIT I: Introduction to Cyber Law & Ethics, Overview of cyber law and its importance, Cybercrimes: Types, legal definitions, and penalties, Ethical considerations in cyberspace, Intellectual property rights (IPR) in the digital domain
- UNIT II: Data Protection & Privacy Laws, General Data Protection Regulation (GDPR) principles and compliance, California Consumer Privacy Act (CCPA) and its impact, India's Digital Personal Data Protection Act (DPDPA) and global privacy regulations, Cross-border data transfer and jurisdictional challenges
- UNIT III: Digital Evidence & Cyber Forensics, Fundamentals of digital forensics and investigation techniques, Collection, preservation, and admissibility of digital evidence, Cybercrime investigation procedures, Role of law enforcement and regulatory bodies
- UNIT IV: Cybersecurity Frameworks & Compliance, Overview of cybersecurity policies and standards (ISO 27001, NIST), Risk management and legal responsibilities in cybersecurity, Compliance requirements for businesses and organizations, Legal aspects of blockchain, artificial intelligence, and emerging technologies
- UNIT V: Case Studies & Emerging Trends, Case studies on major cybersecurity breaches and legal actions, Role of cyber law in digital transformation and e-governance, Future trends: AI ethics, quantum computing security, and global policy developments
- The course incorporates tutorials/case studies/hands-on exercises/interactive learning methods to enhance practical understanding and application.

Recommended Readings:

1. Solove, D. J. *Understanding Privacy*. Harvard University Press.
2. Kerr, O. S. *Computer Crime Law*. West Academic.
3. Global and national cybersecurity policies and regulations.

ITDSE-08: AI-Driven Web & Mobile Application Development
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To integrate AI capabilities in web and mobile applications.
- To develop intelligent applications using modern frameworks.
- To explore real-time applications of AI-driven automation.

Course Learning Outcomes:

1. Design AI-enhanced user experiences for web and mobile apps.
2. Develop applications using AI APIs and frameworks.
3. Implement natural language processing and computer vision in applications.
4. Optimize AI models for performance in mobile and web environments.

Course Contents:

- UNIT I: Introduction to AI-Driven Applications, Overview of AI integration in web and mobile applications, AI in UI/UX: personalization, adaptive interfaces, and behavior-driven design, Conversational AI: chatbots, virtual assistants, and voice-based interactions, AI-powered automation in applications
- UNIT II: Machine Learning for Web & Mobile Applications, Supervised vs. unsupervised learning for application development, Model training, optimization, and deployment strategies, Frameworks for AI integration: TensorFlow.js, TensorFlow Lite, PyTorch Mobile, Cloud-based AI services: Google AI, AWS AI, Azure Cognitive Services
- UNIT III: AI-Enabled Web Development, AI-powered search and recommendation systems (collaborative and content-based filtering), NLP applications: sentiment analysis, automatic translation, and text summarization, Automated UI generation, adaptive A/B testing, and heatmap analysis, AI-enhanced cybersecurity: fraud detection, anomaly detection, and automated threat response
- UNIT IV: Mobile AI & Edge Computing, On-device AI processing vs. cloud-based AI inference, AI model compression techniques (quantization, pruning, knowledge distillation), Real-time image and speech processing for mobile applications, Edge computing frameworks: TensorFlow Lite, Core ML, MediaPipe, OpenVINO
- UNIT V: AI Applications, Deployment & Future Trends, AI in gaming, healthcare, e-commerce, and financial applications, Ethical considerations: bias mitigation, privacy, and security in AI applications, Case studies of AI-powered web and mobile applications, Future trends in AI-driven app development: generative AI, federated learning, and multimodal AI

- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Russell, S., Norvig, P. *Artificial Intelligence: A Modern Approach*. Pearson.
2. Flach, P. *Machine Learning: The Art and Science of Algorithms That Make Sense of Data*. Cambridge University Press.
3. TensorFlow, PyTorch, and AI-driven development documentation.

ITDSE-09: Digital Image Processing
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce fundamental concepts of digital image processing and computer vision.
- To explore image enhancement, restoration, and compression techniques.
- To implement image analysis, segmentation, and object detection.
- To apply deep learning techniques for image classification and recognition.

Course Learning Outcomes:

- Understand the fundamental principles of image processing.
- Implement image enhancement, filtering, and restoration techniques.
- Apply edge detection, segmentation, and object tracking.
- Develop computer vision applications using OpenCV and deep learning frameworks.

Course Contents:

- UNIT I: Introduction to Digital Image Processing, Basics of digital images, color models, and formats, Image sampling, quantization, and resolution
- UNIT II: Image Enhancement & Filtering, Spatial and frequency domain techniques, Histogram equalization, contrast stretching, Smoothing, sharpening, and noise reduction
- UNIT III: Image Segmentation & Feature Extraction, Edge detection (Sobel, Canny, Laplacian), Thresholding and region-based segmentation, Feature descriptors (SIFT, SURF, ORB)
- UNIT IV: Object Detection & Deep Learning for Images, Convolutional Neural Networks (CNNs), Image classification and object detection, Face recognition and real-time video analysis
- UNIT V: Image Compression & Applications, Lossless vs lossy compression (JPEG, PNG, GIF), Video compression (MPEG, H.264), Applications in medical imaging, biometrics, and remote sensing
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Gonzalez, R. C., Woods, R. E. *Digital Image Processing*. Pearson.

2. Szeliski, R. *Computer Vision: Algorithms and Applications*. Springer.
3. Goodfellow, I., Bengio, Y., Courville, A. *Deep Learning*. MIT Press.
4. OpenCV and TensorFlow documentation for image processing and computer vision.

ITDSE-10: Blockchain Development & Smart Contracts
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To introduce blockchain technology and its applications.
- To explore the architecture of distributed ledgers and consensus mechanisms.
- To develop and deploy smart contracts on Ethereum and other blockchain platforms.
- To analyze security, privacy, and scalability challenges in blockchain.

Course Learning Outcomes:
- Explain blockchain fundamentals, consensus mechanisms, and cryptographic principles.
- Develop smart contracts using Solidity and deploy them on Ethereum.
- Implement decentralized applications (DApps) using Web3.js and IPFS.
- Analyze scalability, security, and governance challenges in blockchain.

Course Contents:
- UNIT I: Introduction to Blockchain Technology, Fundamentals of blockchain and distributed ledgers, Cryptographic techniques: hashing, digital signatures, and encryption, Consensus mechanisms (Proof-of-Work, Proof-of-Stake, Byzantine Fault Tolerance)
- UNIT II: Smart Contracts & Solidity Programming, Writing and deploying smart contracts on Ethereum, Solidity programming language: variables, functions, and events, Security vulnerabilities in smart contracts (reentrancy, overflow, etc.)
- UNIT III: Decentralized Applications (DApps) Development, Web3.js integration with smart contracts, Interacting with Ethereum blockchain using Metamask, Storing data on IPFS and other decentralized storage solutions
- UNIT IV: Blockchain Security, Privacy, and Scalability, Privacy-enhancing technologies (zk-SNARKs, Ring Signatures), Layer-2 scaling solutions (Sidechains, State Channels, Rollups), Governance models and enterprise blockchain solutions (Hyperledger, Corda)
- UNIT V: Real-World Applications of Blockchain, Cryptocurrencies and DeFi (Decentralized Finance), NFT (Non-Fungible Tokens) and digital asset tokenization, Blockchain for supply chain, healthcare, and identity management
- The course incorporates tutorials/case studies/hands-on exercises/interactive learning methods to enhance practical understanding and application.

Recommended Readings:
1. Nakamoto, S. *Bitcoin: A Peer-to-Peer Electronic Cash System* (Whitepaper).
2. Antonopoulos, A. M. *Mastering Blockchain*. O'Reilly Media.
3. Dannen, C. *Introducing Ethereum and Solidity: Foundations of Cryptocurrency and Blockchain Programming for Beginners*. Apress.
4. Ethereum, Hyperledger, and Web3.js documentation.

ITDSE-11: Digital Electronics and Internet of Things (IoT)
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To introduce the fundamentals of digital electronics and embedded systems.
- To explore the architecture and working of microcontrollers and IoT devices.
- To develop IoT applications using sensors, actuators, and communication protocols.
- To analyze security challenges and cloud integration in IoT networks.

Course Learning Outcomes:
- Understand digital circuits, logic gates, and microcontroller programming.
- Design and implement IoT applications using sensors and wireless communication.
- Analyze IoT protocols like MQTT, CoAP, and LoRaWAN.
- Evaluate IoT security threats and cloud-based IoT integration.

Course Contents:
- UNIT I: Introduction to Digital Electronics, Number systems, Boolean algebra, and logic gates, Combinational and sequential circuits, Flip-flops, multiplexers, demultiplexers, and memory elements
- UNIT II: Microcontrollers & Embedded Systems, Overview of 8051, AVR, ARM, and ESP32 microcontrollers, Embedded programming in C/C++ and Python, Introduction to real-time operating systems (RTOS)
- UNIT III: Introduction to IoT Architecture, Components of IoT: sensors, actuators, edge devices, IoT communication models and data flow, IoT cloud platforms: AWS IoT, Google Cloud IoT, Azure IoT
- UNIT IV: IoT Protocols and Communication, Wireless communication: Bluetooth, Zigbee, LoRaWAN, Message Queuing Telemetry Transport (MQTT), CoAP, and HTTP, Edge computing and fog computing in IoT
- UNIT V: IoT Security and Applications, Security challenges in IoT networks, Encryption and authentication in IoT devices, Case studies: smart homes, healthcare, and industrial IoT
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Tocci, R. J., Widmer, N. S. *Digital Systems: Principles and Applications*. Pearson.
2. Floyd, T. L. *Digital Fundamentals*. Pearson.
3. Pujol, F. *IoT Security Issues: Threats, Risks, and Countermeasures*. Springer.
4. Al-Fuqaha, A., Guizani, M. *Internet of Things: Architectures, Protocols, and Standards*. Wiley.

ITDSE-12: Digital Forensics & Cyber Threat Intelligence
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To introduce the fundamentals of digital forensics and cyber threat intelligence.
- To explore cybercrime investigation techniques and forensic tools.
- To analyze malware, network intrusions, and threat detection strategies.
- To develop expertise in incident response and legal aspects of digital evidence.

Course Learning Outcomes:

- Explain digital forensic principles and forensic investigation methodologies.
- Analyze malware, logs, and digital footprints for cyber threat intelligence.
- Apply forensic tools like Autopsy, FTK, Wireshark, and Volatility.
- Understand legal frameworks, privacy regulations, and cyber laws.

Course Contents:
- UNIT I: Introduction to Digital Forensics, Basics of digital evidence and forensic investigation process, Types of cybercrimes: hacking, phishing, ransomware, identity theft, Forensic tools and lab setup
- UNIT II: Computer and Network Forensics, Disk imaging, file system analysis, and data recovery, Log analysis and intrusion detection, Network packet analysis using Wireshark
- UNIT III: Malware Analysis & Cyber Threat Intelligence, Static and dynamic malware analysis, Reverse engineering of malware, Threat intelligence frameworks (MITRE ATT&CK, OpenCTI)
- UNIT IV: Incident Response & Cybercrime Investigation, Handling security incidents and forensic reporting, Cloud forensics and IoT forensics, Blockchain forensics and cryptocurrency tracking
- UNIT V: Legal Aspects & Compliance, Digital evidence handling and chain of custody, Cyber laws: GDPR, CCPA, IT Act, 2000, Ethical hacking and forensic challenges
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Casey, E. *Digital Forensics and Cyber Crime*. Elsevier.
2. Nelson, B., Phillips, A., Steuart, C. *Guide to Computer Forensics and Investigations*. Cengage Learning.
3. Easttom, C. *Computer Security Fundamentals*. Pearson.
4. MITRE ATT&CK and NIST Cybersecurity Framework documentation.

ITDSE-13: Explainable AI (XAI) & Model Interpretability
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To introduce the fundamentals of XAI and the need for model interpretability.
- To explore techniques for interpreting ML and deep learning models.
- To analyze trade-offs between accuracy and interpretability in AI models.
- To develop explainable AI models for critical applications like healthcare and finance.

Course Learning Outcomes:
- Understand the importance of XAI and ethical AI principles.
- Apply feature importance, rule-based explanations, and visualization methods.
- Implement post-hoc explainability techniques like SHAP, LIME, and counterfactual explanations.
- Design AI models that are transparent, fair, and interpretable.

Course Contents:

- UNIT I: Introduction to Explainable AI, Importance of model interpretability, Black-box vs white-box models, Ethical considerations in AI decision-making
- UNIT II: Model Interpretability Techniques, Feature importance and decision trees, Partial dependence plots (PDPs) and accumulated local effects (ALE), Counterfactual explanations
- UNIT III: Post-hoc Explainability Methods, Local Interpretable Model-agnostic Explanations (LIME), SHapley Additive exPlanations (SHAP), Integrated Gradients and Saliency Maps for Deep Learning
- UNIT IV: Fairness, Bias, and Trust in AI, Bias detection and mitigation in AI models, Regulatory frameworks for explainability (GDPR, AI Ethics Guidelines), Case studies in healthcare, finance, and law enforcement
- UNIT V: XAI in Real-World Applications, Explainability for NLP models (Transformer-based models like BERT), Explainability in computer vision (CNN visualization techniques), Tools and frameworks for XAI: IBM AI Explainability 360, Google What-If Tool
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Molnar, C. *Interpretable Machine Learning*.
2. Doshi-Velez, F., Kim, B. *Towards A Rigorous Science of Interpretable Machine Learning*.
3. Burkart, N., Huber, M. F. *A Survey on Explainability of Supervised Machine Learning*.
4. Google AI, IBM AI Explainability 360, and OpenAI documentation on model interpretability.

ITDSE-14: Software Engineering & Agile Development
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce software engineering principles and best practices.
- To explore agile methodologies, DevOps, and continuous integration (CI/CD).
- To develop scalable and maintainable software architectures.
- To analyze quality assurance, testing, and software project management.

Course Learning Outcomes:

- Understand SDLC models.
- Apply agile methodologies like Scrum and Kanban for software development.
- Develop and deploy software using CI/CD pipelines and DevOps practices.
- Implement software testing strategies, version control, and documentation.

Course Contents:

- UNIT I: Software Engineering Fundamentals, Software development life cycle (Waterfall, Agile, DevOps), Requirement analysis and software design principles, Object-oriented design and UML diagrams
- UNIT II: Agile Software Development, Agile principles and methodologies (Scrum, Kanban, XP), Sprint planning, backlog grooming, and stand-up meetings, Agile documentation and project tracking tools (JIRA, Trello)

- UNIT III: DevOps and CI/CD, Version control using Git and GitHub, Continuous Integration/Continuous Deployment (Jenkins, GitHub Actions), Containerization and orchestration (Docker, Kubernetes)
- UNIT IV: Software Testing and Quality Assurance, Unit testing, integration testing, system testing, Automated testing frameworks (JUnit, Selenium), Software maintenance and debugging strategies
- UNIT V: Software Project Management & Security, Risk management in software engineering, Secure coding practices and compliance, Case studies on software failures and best practices
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Sommerville, I. *Software Engineering*. Pearson.
2. Pressman, R. S. *Software Engineering: A Practitioner's Approach*. McGraw-Hill.
3. Beck, K. *Extreme Programming Explained: Embrace Change*. Addison-Wesley.
4. Atlassian and Microsoft documentation on Agile and DevOps methodologies.

ITDSE-15: Autonomous Systems & Robotics
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce the fundamentals of autonomous systems and robotics.
- To explore robot perception, motion planning, and control.
- To analyze AI-based decision-making and reinforcement learning for robotics.
- To develop applications in self-driving vehicles, drones, and industrial automation.

Course Learning Outcomes:

- Understand robotic kinematics, dynamics, and control systems.
- Implement sensor fusion techniques for robot perception.
- Apply motion planning and navigation algorithms.
- Develop AI-driven autonomous systems using deep learning and reinforcement learning.

Course Contents:

- UNIT I: Introduction to Autonomous Systems & Robotics, Types of robots (industrial, mobile, humanoid, swarm), Components: actuators, sensors, microcontrollers, Overview of robotic operating systems (ROS)
- UNIT II: Perception and Sensor Fusion, Vision-based sensing (cameras, LiDAR, depth sensors), IMU and GPS-based localization, Sensor fusion using Kalman filters
- UNIT III: Motion Planning & Navigation, Path planning algorithms (A*, Dijkstra, RRT), Simultaneous Localization and Mapping (SLAM), Obstacle avoidance and real-time decision-making
- UNIT IV: AI & Reinforcement Learning for Robotics, Deep learning for robotic perception, Reinforcement learning for control (DQN, PPO, A3C), Applications in self-driving cars, drones, and robotic arms

- UNIT V: Autonomous Systems Applications & Ethics, Self-driving vehicles and industrial automation, Ethics and safety considerations in robotics, Case studies: Boston Dynamics, Tesla Autopilot
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Siciliano, B., Khatib, O. *Springer Handbook of Robotics*. Springer.

2. Thrun, S., Burgard, W., Fox, D. *Probabilistic Robotics*. MIT Press.
3. Sutton, R. S., Barto, A. G. *Reinforcement Learning: An Introduction*. MIT Press.
4. ROS and OpenAI Gym documentation for robotic simulation.

ITDSE-16: NLP & Speech Processing
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To introduce the fundamentals of Natural Language Processing (NLP) and Speech Processing.
- To explore language modeling, text representation, and deep learning techniques for NLP.
- To analyze speech synthesis, recognition, and conversational AI.
- To develop applications in chatbots, machine translation, and voice assistants.

Course Learning Outcomes:
- Understand tokenization, word embeddings, and syntactic parsing.
- Apply transformer-based models like BERT, GPT for NLP tasks.
- Implement speech recognition and text-to-speech (TTS) systems.
- Develop real-world NLP applications in healthcare, finance, and customer support.

Course Contents:
- UNIT I: Introduction to NLP & Speech Processing, Basics of linguistics: syntax, semantics, and pragmatics, Overview of speech processing and phonetics, Applications of NLP in industry
- UNIT II: Text Representation & Language Modeling, Bag-of-Words, TF-IDF, and word embeddings (Word2Vec, GloVe), N-grams, statistical language models, Transformer architectures (BERT, GPT)
- UNIT III: Deep Learning for NLP, Sequence-to-sequence models (RNN, LSTM, GRU), Attention mechanisms and transformer-based NLP, Sentiment analysis, named entity recognition (NER)
- UNIT IV: Speech Recognition & Synthesis, Automatic Speech Recognition (ASR) techniques, Text-to-Speech (TTS) and speech synthesis, Speech enhancement and noise reduction
- UNIT V: Conversational AI & NLP Applications, Chatbot and virtual assistant development, Machine translation (Google Translate, DeepL), Ethical challenges in NLP (bias, misinformation)

- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Jurafsky, D., Martin, J. H. *Speech and Language Processing*. Pearson.
2. Goldberg, Y. *Neural Network Methods for Natural Language Processing*. Morgan & Claypool.
3. Vaswani, A. et al. *Attention Is All You Need* (Transformer Paper).
4. Hugging Face and TensorFlow documentation on NLP models.

ITDSE-17: Deep Learning for Computer Vision
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce the fundamentals of deep learning for computer vision.
- To explore CNNs and modern deep learning architectures.
- To analyze object detection, segmentation, and image generation techniques.
- To develop real-world applications in autonomous systems, healthcare, and biometrics.

Course Learning Outcomes:

- Understand CNN architectures and their applications in vision tasks.
- Implement transfer learning and fine-tuning for image classification.
- Apply object detection (YOLO, Faster R-CNN) and image segmentation (U-Net, Mask R-CNN).
- Develop computer vision applications using TensorFlow, PyTorch, and OpenCV.

Course Contents:

- UNIT I: Introduction to Deep Learning for Computer Vision, Fundamentals of image processing and feature extraction, Overview of neural networks and deep learning, Evolution of CNNs for vision tasks
- UNIT II: Convolutional Neural Networks & Feature Learning, Convolution, pooling, and activation functions, Architectures: AlexNet, VGG, ResNet, DenseNet, Transfer learning and fine-tuning for vision tasks
- UNIT III: Object Detection & Image Segmentation, Object detection models: YOLO, SSD, Faster R-CNN, Image segmentation: U-Net, Mask R-CNN, Applications in medical imaging and autonomous systems
- UNIT IV: Generative Models & Advanced Techniques, Generative Adversarial Networks (GANs) for image synthesis, Variational Autoencoders (VAEs), Image super-resolution and style transfer
- UNIT V: Computer Vision Applications & Deployment, Face recognition and biometrics, AI-powered video analytics, Deployment of vision models on edge devices (TensorFlow Lite, NVIDIA Jetson)
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Goodfellow, I., Bengio, Y., Courville, A. *Deep Learning*. MIT Press.

2. Chollet, F. *Deep Learning with Python*. Manning Publications.
3. Szeliski, R. *Computer Vision: Algorithms and Applications*. Springer.
4. TensorFlow, PyTorch, and OpenCV documentation for deep learning models.

ITDSE-18: Digital Health Informatics
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To introduce digital health informatics and healthcare data analytics.
- To explore electronic health records (EHR), medical imaging, and telemedicine.
- To analyze AI-driven diagnostics, predictive modeling, and wearable health monitoring.
- To understand privacy, security, and ethical considerations in digital health.

Course Learning Outcomes:
- Understand health informatics concepts, standards, and interoperability.
- Apply machine learning techniques to healthcare data.
- Implement AI-powered diagnostics and decision-support systems.
- Evaluate privacy, security, and compliance challenges in health informatics.

Course Contents:
- UNIT I: Introduction to Digital Health Informatics, Overview of healthcare data and health informatics, Electronic Health Records (EHR) and interoperability (HL7, FHIR), Telemedicine and mobile health (mHealth)
- UNIT II: AI & Machine Learning in Healthcare, Predictive modeling for disease progression, AI-driven diagnostics and clinical decision support systems, Personalized medicine and genomics
- UNIT III: Medical Imaging & AI, Deep learning applications in radiology and pathology, AI-based medical image segmentation and classification, Case studies: AI for cancer detection, retinal disease screening
- UNIT IV: Wearable & IoT-based Healthcare Systems, Smart health monitoring devices (smartwatches, biosensors), IoT-based real-time patient monitoring, Data processing and analytics in wearable health tech
- UNIT V: Privacy, Security, and Ethical Issues in Digital Health, HIPAA, GDPR, and data protection regulations, Cybersecurity threats in healthcare systems, Ethical challenges in AI-driven healthcare
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:
1. Shortliffe, E. H., Cimino, J. J. *Biomedical Informatics: Computer Applications in Health Care and Biomedicine*. Springer.
2. Patel, V. L., Kannampallil, T. G., Kaufman, D. R. *Cognitive Informatics for Biomedicine*. Springer.
3. Dey, N., Ashour, A. S., Borra, S. *Big Data Analytics for Intelligent Healthcare Management*. Elsevier.
4. WHO, HIMSS, and NIST guidelines on digital health and informatics.

ITDSE-19: Cloud Computing & DevOps

Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce cloud computing fundamentals and architecture.
- To explore virtualization, containerization, and cloud service models (IaaS, PaaS, SaaS).
- To develop expertise in DevOps practices, CI/CD, and infrastructure automation.
- To analyze cloud security, monitoring, and cost optimization strategies.

Course Learning Outcomes:

- Understand cloud computing models, providers, and deployment strategies.
- Implement containerized applications using Docker and Kubernetes.
- Apply CI/CD pipelines, infrastructure as code (IaC), and DevOps best practices.
- Evaluate cloud security risks, compliance, and scalability considerations.

Course Contents:

- UNIT I: Introduction to Cloud Computing, Fundamentals of cloud computing and its evolution, Cloud service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Cloud deployment models: Public, Private, Hybrid, and Multi-cloud, Overview of major cloud providers: AWS, Azure, Google Cloud
- UNIT II: Virtualization & Containerization, Hypervisors, Virtual Machines (VMs), and resource allocation, Docker fundamentals, Container orchestration with Kubernetes, Serverless computing and Function-as-a-Service (FaaS)
- UNIT III: Principles of DevOps and agile software development, Continuous Integration/Continuous Deployment (CI/CD) pipelines, Automation tools: Jenkins, GitHub Actions, GitLab CI/CD, Infrastructure as Code (IaC) using Terraform and Ansible
- UNIT IV: Cloud Monitoring, Scaling & Cost Optimization, Cloud resource scaling: Auto-scaling and load balancing, Cloud monitoring tools: Prometheus, Grafana, AWS CloudWatch, Cost management strategies and resource allocation optimization, Cloud security best practices
- UNIT V: Advanced Cloud Technologies & Case Studies, Edge computing and its role in cloud ecosystems, AI and Machine Learning integration in cloud services, Case studies on cloud adoption in enterprises, Future trends: Quantum cloud computing and cloud sustainability
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Erl, T. *Cloud Computing: Concepts, Technology & Architecture*. Pearson.
2. Hüttermann, M. *DevOps for Developers*. Apress.
3. Burns, B. *Kubernetes: Up & Running*. O'Reilly Media.
4. AWS, Azure, and Google Cloud documentation on cloud computing and DevOps.

ITDSE-20: Introduction to the Theory of Computation

Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce formal models of computation and automata theory.
- To explore computability, complexity classes, and Turing machines.
- To analyze decidability, NP-completeness, and P vs NP problem.
- To develop a mathematical foundation for algorithmic analysis.

Course Learning Outcomes:

- Understand finite automata, regular languages, and context-free grammars.
- Apply Turing machines and computational complexity theories.
- Analyze problems related to decidability and intractability.
- Solve computational problems using formal models of computation.

Course Contents:

- UNIT I: Introduction to Automata Theory, Deterministic and Non-Deterministic Finite Automata (DFA, NFA), Regular expressions and their equivalence to finite automata, Pumping lemma for regular languages, Applications of automata in lexical analysis and text processing
- UNIT II: Context-Free Grammars & Pushdown Automata incorporating Chomsky hierarchy of languages, Context-Free Grammars (CFG) and their properties, Pushdown Automata (PDA) and their equivalence to CFG, Parsing algorithms and applications in programming languages and compilers
- UNIT III: Turing Machines & Computability incorporating Definition and components of a Turing Machine, Universal computation and the Church-Turing thesis, Decidability, undecidability, and the Halting problem, Gödel's incompleteness theorem and implications for computation
- UNIT IV: Complexity Theory & NP-Completeness incorporating Time complexity analysis and Big-O notation, Complexity classes: P, NP, NP-hard, and NP-complete, Polynomial-time reductions and Cook's theorem, Introduction to approximation algorithms
- UNIT V: Advanced Topics in Computation Theory incorporating Quantum computing and post-classical computation models, Applications of computational theory in artificial intelligence and cryptography, Complexity theory in modern computing: P vs NP problem, Open problems and future research directions in theoretical computer science
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Hopcroft, J. E., Motwani, R., Ullman, J. D. *Introduction to Automata Theory, Languages, and Computation*. Pearson.
2. Sipser, M. *Introduction to the Theory of Computation*. Cengage Learning.
3. Arora, S., Barak, B. *Computational Complexity: A Modern Approach*. Cambridge University Press.
4. Goldreich, O. *Computational Complexity: A Conceptual Perspective*. MIT Press.

ITDSE-21: Algorithms and Compution

Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce algorithms and probabilistic techniques in computing.
- To explore Monte Carlo, Las Vegas, and Markov chain-based algorithms.
- To analyze probabilistic data structures and hashing techniques.
- To develop efficient algorithms for large-scale data analysis.

Course Learning Outcomes:

- Understand randomized techniques for algorithm optimization.
- Apply probabilistic methods to computational problems.
- Analyze Markov chains, stochastic processes, and Bayesian inference.
- Implement randomized algorithms for real-world applications.

Course Contents:

- UNIT I: Introduction to Algorithms incorporating Deterministic vs. randomized algorithms, Monte Carlo, Las Vegas, Random number generation and pseudo-randomness, Probabilistic analysis of algorithms
- UNIT II: Markov chains and their applications incorporating Random walks and applications in graph theory, Bayesian inference and probabilistic reasoning, Basics of queuing theory: M/M/1 and M/G/1 queues
- UNIT III: Randomized Data Structures & Hashing incorporating Bloom filters and probabilistic data structures, Universal hashing and hash tables, Skip lists and treaps, Randomized search trees
- UNIT IV: Graph Theory incorporating Randomized min-cut and shortest path algorithms, PageRank algorithm and web search ranking, Applications of randomization in graph processing
- UNIT V: Applications of Algorithms in Computing, Cryptographic protocols and zero-knowledge proofs, Quantum computing and probabilistic approaches, Randomized algorithms in machine learning and AI, Real-world applications in big data processing and optimization
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Motwani, R., Raghavan, P. *Randomized Algorithms*. Cambridge University Press.
2. Mitzenmacher, M., Upfal, E. *Probability and Computing: Randomized Algorithms and Probabilistic Analysis*. Cambridge University Press.
3. Vazirani, V. *Approximation Algorithms*. Springer.
4. Cormen, T. H., Leiserson, C. E., Rivest, R. L., Stein, C. *Introduction to Algorithms*. MIT Press.

Masters of Science in Informatics – M.Sc. (Informatics)
General Elective Courses

ITGE01: Introduction to Computational Thinking & Problem Solving
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To introduce the principles of computational thinking and structured problem-solving.
- To develop algorithmic thinking and logical reasoning skills.
- To explore basic programming concepts and applications in various domains.
- To analyze problem decomposition, pattern recognition, and abstraction techniques.

Course Learning Outcomes:
- Understand computational thinking concepts and their applications.
- Apply problem-solving strategies using algorithms and programming.
- Implement basic coding techniques in Python and pseudocode.
- Analyze real-world problems using computational models.

Course Contents:
- UNIT I: Fundamentals of Computational Thinking – Decomposition, pattern recognition, abstraction, and algorithms, Problem-solving strategies and heuristic approaches, Examples of computational thinking in science, business, and social sciences
- UNIT II: Algorithmic Thinking & Pseudocode – Steps of algorithm design and optimization, Flowcharts, decision trees, and recursion, Sorting and searching algorithms
- UNIT III: Introduction to Programming & Logic – Variables, loops, functions, and control structures, Debugging and error handling, Algorithmic efficiency and complexity analysis
- UNIT IV: Computational Models & Real-World Applications – Graph theory, game theory, and network analysis, Applications in bioinformatics, cryptography, and finance, Computational thinking for AI and automation
- UNIT V: Future of Computational Thinking & AI Integration – Role of computation in emerging technologies, Ethics and societal impact of automation, Case studies and project-based learning
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Wing, J. M. *Computational Thinking*. ACM Journal.
2. Lee, J., Lodi, A. *Computational Thinking in Education: Foundations and Research Perspectives*. Springer.
3. Python documentation and introductory programming resources.
4. Grok Learning and Code.org materials on computational problem-solving.

ITGE02: Digital Humanities & Computational Social Sciences
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce the interdisciplinary field of digital humanities and computational social sciences.
- To explore data-driven approaches to analyzing cultural, historical, and social phenomena.
- To develop text analysis, network science, and visualization techniques.
- To examine ethical considerations in digital research methodologies.

Course Learning Outcomes:
- Understand how computational tools are applied in humanities and social sciences.
- Analyze large-scale text, media, and social network datasets.
- Apply machine learning, NLP, and data visualization techniques.
- Evaluate ethical and privacy concerns in digital humanities research.

Course Contents:
- UNIT I: Introduction to Digital Humanities & Computational Social Sciences – Overview of digital humanities and computational methodologies, Historical, cultural, and political applications of data science, Tools for digital research
- UNIT II: Text Mining & Sentiment Analysis – NLP for humanities research, Topic modeling and stylometry (author identification), Sentiment analysis in social media and political discourse
- UNIT III: Social Network Analysis & Computational Sociology – Graph theory and network visualization, Case studies on misinformation, polarization, and online behavior, Ethical challenges in digital social science research
- UNIT IV: Big Data, AI, and Ethics in Humanities – Digital archives and knowledge representation, AI-generated literature and automated translation, Privacy, surveillance, and digital rights in cultural studies
- UNIT V: Future of Computational Humanities & Social Sciences – Interactive storytelling and augmented reality in digital humanities, Case studies in history, linguistics, and media studies, Project-based learning using computational tools for social impact
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:
1. Berry, D. M. *Understanding Digital Humanities*. Palgrave Macmillan.
2. Moretti, F. *Distant Reading*. Verso Books.
3. Lazer, D., Pentland, A., et al. *Computational Social Science*. Science Journal.
4. Stanford NLP and Gephi documentation for text and network analysis.

ITGE03: Ethical AI & Bias Mitigation in Machine Learning
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To introduce the ethical challenges and societal impact of AI and machine learning.
- To explore bias detection and fairness-enhancing techniques in AI systems.
- To analyze AI governance frameworks and regulatory policies.
- To develop strategies for building fair, transparent, and accountable AI models.

Course Learning Outcomes:

- Understand bias sources in AI models and their consequences.
- Apply mathematical fairness metrics and debiasing techniques.
- Implement XAI methods for transparency and interpretability.
- Evaluate ethical AI frameworks and regulatory policies.

Course Contents:

- UNIT I: Introduction to AI Ethics & Bias – Ethical considerations in AI development, Case studies: AI discrimination in hiring, healthcare, and policing, Legal and societal impact of biased AI
- UNIT II: Fairness, Accountability & Transparency in AI – Fairness metrics: demographic parity, equal opportunity, individual fairness, Interpretability techniques (LIME, SHAP, counterfactual explanations), Transparency challenges in deep learning models
- UNIT III: Bias Mitigation Techniques in Machine Learning – Pre-processing, in-processing, and post-processing bias mitigation, Algorithmic fairness techniques (reweighing, adversarial debiasing), Differential privacy and federated learning for ethical AI
- UNIT IV: AI Regulation, Governance, and Compliance – Global AI regulations: GDPR, CCPA, IEEE AI Ethics Guidelines, AI auditing frameworks and model risk management, Explainability and accountability in AI decision-making
- UNIT V: Ethical AI in Practice & Future Trends – Human-in-the-loop AI and ethical decision support systems, AI for social good: fairness in healthcare, finance, and law, The future of ethical AI and bias-free machine learning
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Binns, R. *Fairness in Machine Learning: Lessons from Political Philosophy*. ACM.
2. O'Neil, C. *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy*. Crown Publishing.
3. Russell, S., Norvig, P. *Artificial Intelligence: A Modern Approach*. Pearson.
4. IBM AI Fairness 360, Google AI Ethics, and EU AI Act documentation.

ITGE04: Ethical AI & Responsible Tech Development

Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce ethical considerations in AI and emerging technologies.
- To explore the societal impact of AI, automation, and digital transformation.
- To analyze bias, transparency, and accountability in AI systems.
- To develop frameworks for responsible AI governance and technology ethics.

Course Learning Outcomes:

- Understand ethical challenges in AI and responsible tech innovation.
- Analyze bias, fairness, and transparency issues in machine learning models.
- Apply ethical frameworks and regulations for responsible AI governance.

- Develop AI solutions with human-centered, fair, and inclusive design principles.

Course Contents:

- UNIT I: Introduction to AI Ethics & Responsible Tech Development – Ethical dilemmas in AI and automation, Societal risks of AI, automation, and decision-making algorithms, Case studies on ethical AI failures (e.g., facial recognition bias, hiring AI discrimination)
- UNIT II: Bias, Fairness & Transparency in AI – Algorithmic bias and fairness metrics, Interpretability and explainable AI (XAI) techniques, Trustworthy AI: transparency, reliability, and user accountability
- UNIT III: Regulatory Frameworks & AI Governance – Ethical AI policies: IEEE AI Ethics Guidelines, EU AI Act, and OECD AI Principles, Privacy laws and compliance (GDPR, CCPA, HIPAA), AI auditing, risk management, and accountability
- UNIT IV: Human-Centered AI & Inclusive Technology – Ethical design principles for AI systems, Digital inclusion, accessibility, and fairness in AI, The role of stakeholders in AI-driven decision-making
- UNIT V: Future of Responsible Tech Development – AI for social good and sustainability, Emerging trends in ethical AI, automation, and human-AI collaboration, Case studies: ethical AI in healthcare, education, and governance
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. O'Neil, C. *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy*. Crown Publishing.
2. Binns, R. *Fairness in Machine Learning: Lessons from Political Philosophy*. ACM.
3. Russell, S. *Human Compatible: Artificial Intelligence and the Problem of Control*. Penguin Random House.
4. IEEE AI Ethics, EU AI Act, and IBM AI Fairness 360 documentation.

ITGE05: Augmented Reality (AR) & Virtual Reality (VR)

Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce fundamentals of Augmented Reality (AR) and Virtual Reality (VR).
- To explore hardware and software development for immersive experiences.
- To analyze applications of AR/VR in gaming, education, healthcare, and industrial training.
- To develop interactive AR/VR applications using Unity, Unreal Engine, and WebXR.

Course Learning Outcomes:

- Understand the core principles of AR/VR systems and immersive environments.
- Develop interactive 3D applications using Unity, Unreal Engine, and WebXR.
- Implement gesture recognition, spatial computing, and mixed reality interactions.
- Evaluate usability, accessibility, and ethical considerations in AR/VR design.

Course Contents:

- UNIT I: Introduction to AR/VR Technologies – Differences between AR, VR, and Mixed Reality (MR), Components of immersive environments: hardware, software, sensors, Applications in gaming, healthcare, education, and enterprise
- UNIT II: AR/VR Development Frameworks – Development tools: Unity, Unreal Engine, ARKit, ARCore, Web-based AR/VR (A-Frame, WebXR), 3D modeling, rendering, and physics engines
- UNIT III: User Interaction & HCI in AR/VR – Gesture recognition and spatial computing, Eye-tracking and haptic feedback, Designing intuitive and immersive experiences
- UNIT IV: Advanced AR/VR Applications & Future Trends – AI-driven AR/VR experiences (computer vision, real-time object recognition), 5G, cloud gaming, and VR streaming, Ethical concerns: privacy, security, and accessibility in AR/VR
- UNIT V: AR/VR in Industry & Research – Industrial training and simulation (healthcare, automotive, military), Augmented reality for smart cities and digital twins, The future of metaverse and AR/VR social platforms
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Craig, A. B. *Understanding Augmented Reality: Concepts and Applications*. Elsevier.
2. Burdea, G., Coiffet, P. *Virtual Reality Technology*. Wiley.
3. Sherman, W. R., Craig, A. B. *Understanding Virtual Reality: Interface, Application, and Design*. Morgan Kaufmann.
4. Unity, Unreal Engine, and WebXR documentation on AR/VR development.

ITGE06: Assistive Technologies & Digital Accessibility

Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce assistive technologies and their role in accessibility.
- To explore universal design principles for digital accessibility.
- To analyze AI-driven assistive technologies for individuals with disabilities.
- To develop inclusive technologies that enhance digital equity.

Course Learning Outcomes:

- Understand the importance of assistive technologies for digital accessibility.
- Apply universal design principles in web and mobile applications.
- Implement AI-powered accessibility tools for visually and hearing-impaired users.
- Evaluate compliance with accessibility laws and standards (WCAG, ADA, Section 508).

Course Contents:

- UNIT I: Introduction to Assistive Technologies & Accessibility – Definition and types of assistive technologies, Accessibility barriers and digital inclusion, Case studies on inclusive technology design
- UNIT II: Universal Design Principles & Accessibility Guidelines – Web Content Accessibility Guidelines (WCAG), Accessible web and mobile UI/UX design, Best practices for inclusive digital experiences

- UNIT III: AI & Machine Learning for Accessibility – AI-powered screen readers and speech-to-text applications, Computer vision-based assistive solutions (e.g., Seeing AI, Google Lens), NLP-based conversational AI for accessibility (voice assistants, chatbots)
- UNIT IV: Wearable & Smart Assistive Devices – Smart prosthetics, brain-computer interfaces (BCIs), AR/VR-based assistive tools for cognitive disabilities, Eye-tracking and gesture-based control interfaces
- UNIT V: Challenges & Future Trends in Digital Accessibility – Ethical issues in assistive tech development, Emerging innovations in smart accessibility devices, The role of AI and IoT in next-gen accessibility solutions
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Cooper, M., Sloan, D., Kelly, B. *Digital Accessibility: Enabling Inclusion & Usability*. Springer.
2. Mace, R. *Universal Design Handbook*. McGraw-Hill.
3. Treviranus, J. *Inclusive Design for a Digital World: Designing with Accessibility in Mind*. Apress.
4. W3C, WebAIM, and WCAG documentation on accessibility standards.

ITGE07: Green Computing & Sustainable Technology

Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce the principles of green computing and sustainable technology.
- To explore energy-efficient computing practices and eco-friendly IT solutions.
- To analyze sustainability challenges in hardware, software, and data centers.
- To develop strategies for reducing carbon footprints in technology use.

Course Learning Outcomes:

- Understand energy-efficient computing architectures and hardware design.
- Implement sustainable software development practices.
- Analyze the environmental impact of cloud computing and data centers.
- Develop green IT policies for organizations and industries.

Course Contents:

- UNIT I: Introduction to Green Computing & Sustainable IT – Definition and need for sustainable computing, Environmental impact of technology production and usage, Principles of energy-efficient computing
- UNIT II: Sustainable Hardware & Infrastructure – Energy-efficient processors, memory, and power management, E-waste management and recycling strategies, Green data centers and energy optimization
- UNIT III: Sustainable Software Engineering – Eco-friendly coding practices, Power-aware computing and load balancing, Sustainable lifecycle management for IT products

- UNIT IV: Cloud Computing & Sustainability – Environmental challenges in cloud and edge computing, Energy-efficient virtualization and containerization, Carbon-neutral data storage and processing
- UNIT V: Green IT Policies & Future Trends – Corporate sustainability initiatives, Policy frameworks and global regulations (e.g., Green IT, ESG compliance), Emerging trends: biodegradable electronics, carbon-aware computing
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Murugesan, S. *Harnessing Green IT: Principles and Practices*. Wiley.
2. Hanks, K. *Sustainable IT Playbook for Technology Leaders*. O'Reilly.
3. Patterson, D. A. *The Datacenter as a Computer: An Introduction to the Design of Warehouse-Scale Machines*. Morgan & Claypool.
4. Reports from the UN, IEEE, and corporate sustainability policies on green IT.

ITGE08: Advanced Robotics & Human-AI Collaboration

Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce robotics principles, automation, and human-robot interaction.
- To explore robotic system design, control, and real-world applications.
- To analyze collaborative robotics and its role in industries and society.
- To develop strategies for ethical and safe human-robot collaboration.

Course Learning Outcomes:

- Understand fundamental robotics concepts and control mechanisms.
- Implement robotic motion planning and kinematics.
- Analyze the impact of collaborative robots (cobots) in industrial and service sectors.
- Evaluate ethical and safety considerations in human-robot interaction.

Course Contents:

- UNIT I: Introduction to Robotics & Automation – Basic components of robotic systems, Actuators, sensors, and robotic controllers, Role of automation in industries and everyday life
- UNIT II: Kinematics, Motion Planning & Control – Forward and inverse kinematics, Robotic path planning and obstacle avoidance, Control algorithms for robotic arms and mobile robots
- UNIT III: Human-Robot Interaction & Collaborative Robotics – Role of cobots in manufacturing, healthcare, and services, Safety and ergonomic considerations in human-robot collaboration, Social and emotional aspects of human-robot interaction
- UNIT IV: Industrial & Service Robotics Applications – Robotics in logistics, healthcare, agriculture, and defense, Exoskeletons, wearable robotics, and prosthetics, Autonomous systems in transportation and smart cities
- UNIT V: Ethical, Legal, and Safety Aspects in Robotics – Workplace automation and labor market effects, Safety regulations and compliance for robotics, Future trends: swarm robotics, soft robotics, and biomimetic robots

- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Siciliano, B., Khatib, O. *Springer Handbook of Robotics*. Springer.
2. Craig, J. *Introduction to Robotics: Mechanics and Control*. Pearson.
3. Brynjolfsson, E., McAfee, A. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. Norton.
4. Reports from IEEE Robotics and Automation Society, ISO Robotics Safety Standards.

ITGE09: Social Network Analysis & Computational Propaganda
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce social network analysis (SNA) and its applications.
- To explore the impact of digital networks on public opinion and misinformation.
- To analyze computational propaganda techniques and social media manipulation.
- To develop methods for detecting and mitigating information disorder in online spaces.

Course Learning Outcomes:

- Understand social network structures, metrics, and algorithms.
- Analyze social media influence, virality, and misinformation dynamics.
- Implement graph-based techniques for network visualization and community detection.
- Evaluate ethical, legal, and regulatory challenges in digital communication.

Course Contents:

- UNIT I: Introduction to Social Network Analysis– Basics of graph theory and network structures, Centrality, clustering, and small-world networks, Applications of SNA in sociology, politics, and business
- UNIT II: Computational Propaganda & Social Media Manipulation – Misinformation, disinformation, and fake news, Automated bots, trolls, and coordinated inauthentic behavior, Influence campaigns and algorithmic amplification
- UNIT III: Network Visualization & Community Detection – Tools for analyzing social graphs (Gephi, NetworkX), Detection of echo chambers and filter bubbles, Case studies on viral trends and online movements
- UNIT IV: AI & Algorithmic Bias in Social Media – Role of recommendation algorithms in shaping opinions, Personalization, surveillance, and privacy concerns, Ethical considerations in digital influence and persuasion
- UNIT V: Regulation, Policy & Future of Digital Communication – Government and corporate responses to online misinformation, Media literacy and digital resilience initiatives, Future trends in networked communication and online governance
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Watts, D. J. *Six Degrees: The Science of a Connected Age*. W.W. Norton & Company.

2. Tufekci, Z. *Twitter and Tear Gas: The Power and Fragility of Networked Protest*. Yale University Press.
3. Ferrara, E., Varol, O., et al. *The Rise of Social Bots*. Communications of the ACM.
4. Reports from the Oxford Internet Institute, Pew Research Center, and Global Disinformation Index.

ITGE10: Cyber-Physical Systems & Smart Infrastructure
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce the concept of Cyber-Physical Systems (CPS) and their role in modern infrastructure.
- To explore integrated hardware-software systems for monitoring and automation.
- To analyze connectivity, security, and resilience in smart infrastructure.
- To evaluate the impact of digital transformation on urban planning and industries.

Course Learning Outcomes:

- Understand CPS architecture and applications.
- Implement communication protocols and interoperability frameworks in smart systems.
- Analyze security challenges and reliability considerations in CPS.
- Evaluate smart infrastructure applications in transportation, energy, and healthcare.

Course Contents:

- UNIT I: Introduction to Cyber-Physical Systems – Definition and characteristics of CPS, Integration of physical and digital systems, CPS in industrial automation, healthcare, and urban planning
- UNIT II: Smart Infrastructure & Connected Systems – Smart cities, intelligent transportation, and energy grids, IoT and sensor networks in infrastructure management, Case studies: smart buildings, water management, and disaster resilience
- UNIT III: Security & Privacy in Cyber-Physical Systems – Threats and vulnerabilities in CPS, Security frameworks and risk management, Compliance with regulations and ethical considerations
- UNIT IV: Communication & Interoperability in CPS – Wireless networks and industrial communication protocols, Edge computing and real-time decision-making, System integration challenges and standardization efforts
- UNIT V: Sustainability & Future Trends in CPS – Role of CPS in environmental sustainability, Digital twins and predictive analytics for infrastructure, Future trends: autonomous transportation, adaptive infrastructure
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Baheti, R., Gill, H. *Cyber-Physical Systems*. IEEE.
2. Rajkumar, R., Lee, I., et al. *Cyber-Physical Systems: The Next Computing Revolution*. ACM.
3. Zanero, S. *Security in Cyber-Physical Systems*. Springer.
4. Reports from Smart Cities Council, NIST CPS Framework, and IEEE standards.

ITGE11: Future of Work: AI, Automation & Digital Labor
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To examine the impact of technological advancements on employment and workforce dynamics.
- To explore automation, remote work, and digital labor trends.
- To analyze the role of digital platforms in the gig economy and global workforce.
- To evaluate the ethical, social, and economic implications of technological shifts.

Course Learning Outcomes:
- Understand the transformation of labor markets in the digital age.
- Analyze the impact of automation on different industries and job roles.
- Evaluate strategies for workforce adaptation and skill development.
- Examine global labor policies and regulations in the digital economy.

Course Contents:
- UNIT I: Introduction to the Future of Work – Historical perspectives on technological disruption, Changing nature of employment and digital workspaces, Workforce digitalization and emerging job roles
- UNIT II: Automation & Workforce Transformation – Industrial automation and robotics in manufacturing, Service automation and the rise of digital assistants, Ethical concerns: job displacement vs job augmentation
- UNIT III: Gig Economy & Digital Labor Platforms – Online freelancing, remote work, and global talent pools, Labor rights and fair compensation in digital work, Platform governance and worker protections
- UNIT IV: Workplace Culture & Skills for the Future – Hybrid work models and organizational shifts, Digital literacy and lifelong learning, Reskilling and upskilling strategies for workers
- UNIT V: Policy, Ethics & Societal Impact – Economic policies and labor market regulations, Universal basic income and alternative employment models, Future outlook: balancing technological progress with workforce inclusion
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Brynjolfsson, E., McAfee, A. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. Norton.
2. Ford, M. *The Rise of the Robots: Technology and the Threat of Mass Unemployment*. Basic Books.
3. Srnicek, N. *Platform Capitalism*. Polity Press.
4. Reports from the World Economic Forum, International Labour Organization, and McKinsey Global Institute on the future of work.

ITGE12: Introduction to Human-Computer Interaction (HCI)
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce fundamental concepts of Human-Computer Interaction.
- To explore usability principles, interaction design, and user experience.
- To analyze cognitive, social, and ergonomic aspects of system design.
- To develop an understanding of evaluation methods for interactive systems.

Course Learning Outcomes:

- Understand HCI principles and user-centered design methodologies.
- Apply usability testing and UX evaluation techniques.
- Develop effective interaction designs for various platforms.
- Analyze accessibility, inclusivity, and emerging trends in HCI.

Course Contents:

- UNIT I: Introduction to Human-Computer Interaction – Evolution and importance of HCI, Interaction paradigms (command-based, graphical, multimodal interfaces), User experience (UX) and usability principles
- UNIT II: Designing Interactive Systems – User-centered design (UCD) and participatory design, Affordances, mental models, and feedback mechanisms, Interface design patterns and heuristics
- UNIT III: Cognitive & Social Aspects of HCI – Cognitive load, attention, and perception in interaction, Social computing and collaborative technologies, Ethics and privacy concerns in interaction design
- UNIT IV: Usability Testing & UX Evaluation – Usability heuristics (Nielsen's principles), A/B testing and user studies, Eye-tracking and biometric feedback in usability research
- UNIT V: Emerging Trends & Future of HCI – Augmented reality (AR), virtual reality (VR), and mixed reality (MR), Conversational interfaces (voice assistants, chatbots), Accessibility and inclusive design for diverse users
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Norman, D. *The Design of Everyday Things*. Basic Books.
2. Shneiderman, B., Plaisant, C. *Designing the User Interface: Strategies for Effective Human-Computer Interaction*. Pearson.
3. Rogers, Y., Sharp, H., Preece, J. *Interaction Design: Beyond Human-Computer Interaction*. Wiley.
4. Research papers from ACM SIGCHI and IEEE on emerging HCI trends.

ITGE13: Research Methodology & Scientific Writing

Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce fundamental principles of research methodology.
- To explore qualitative and quantitative research techniques.
- To develop skills for scientific writing, academic publishing, and research ethics.

- To analyze data interpretation, literature review, and citation management.

Course Learning Outcomes:

- Understand different research methods and approaches.
- Conduct systematic literature reviews and critical analyses.
- Develop effective scientific writing and publication strategies.
- Apply ethical considerations and best practices in research.

Course Contents:

- UNIT I: Introduction to Research Methodology – Definition and scope of research, Types of research (exploratory, descriptive, analytical, experimental), Research process and problem formulation
- UNIT II: Qualitative & Quantitative Research Methods – Data collection techniques (surveys, interviews, case studies), Statistical methods, hypothesis testing, and inferential analysis, Mixed-method research and triangulation techniques
- UNIT III: Scientific Writing & Literature Review – Structuring research papers, reports, and theses, Writing effective abstracts, introductions, and conclusions, Managing references with citation tools (Mendeley, Zotero, EndNote)
- UNIT IV: Publication & Ethical Considerations – Journal selection, peer review process, and impact factors, Plagiarism, authorship ethics, and academic integrity, Research funding, proposals, and grant writing
- UNIT V: Data Interpretation & Visualization – Statistical analysis and data representation, Using software tools for data analysis (SPSS, R, Python), Best practices in presenting findings through tables, charts, and infographics
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Creswell, J. W. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Sage.
2. Kothari, C. R. *Research Methodology: Methods and Techniques*. New Age International.
3. Day, R. A. *How to Write and Publish a Scientific Paper*. Cambridge University Press.
4. Publications from Springer, IEEE, and Elsevier on academic writing and research methods.

Masters of Science in Informatics – M.Sc. (Informatics)
Research Methods/ Tools/Writing

ITR01: Advanced Research Methodology of Informatics
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To introduce various qualitative and quantitative data collection methods.
- To explore sampling techniques, survey design, and interview methodologies.
- To analyze ethical considerations and challenges in data collection.
- To develop skills for data acquisition, preprocessing, and management.

Course Learning Outcomes:
- Understand primary and secondary data collection techniques.
- Design and conduct surveys, interviews, and observational studies.
- Apply data validation, cleaning, and preprocessing methods.
- Evaluate ethical considerations and data security best practices.

Course Contents:
- UNIT I: Introduction to Data Collection – Importance of data collection in research, Difference between primary and secondary data, Reliability, validity, and biases in data collection
- UNIT II: Qualitative Data Collection Methods – Interviews (structured, semi-structured, unstructured), Focus groups and ethnographic studies, Case studies and document analysis
- UNIT III: Quantitative Data Collection Techniques – Surveys and questionnaire design, Experiments and observational research, Sampling methods (probability and non-probability sampling)
- UNIT IV: Data Management & Preprocessing – Data validation and cleaning techniques, Handling missing data and outliers, Ethical considerations in data collection
- UNIT V: Technological Tools for Data Collection – Online survey tools (Google Forms, Qualtrics, SurveyMonkey), Mobile data collection and IoT-based sensors, Data repositories and open-access databases
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:
1. Creswell, J. W. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Sage.
2. Babbie, E. *The Practice of Social Research*. Cengage Learning.
3. Fowler, F. J. *Survey Research Methods*. Sage.
4. Reports and guidelines from UNESCO, WHO, and Data.gov on ethical data collection.

ITR02: Tools for Research
Marks: 100 | Duration: 60 Hrs

Course Objectives:

- To introduce the importance of citation management in research.
- To explore different citation styles and formatting techniques.
- To provide hands-on training on reference management tools.
- To develop skills for avoiding plagiarism and ensuring academic integrity.

Course Learning Outcomes:

- Understand the role of citations and proper attribution in research.
- Apply various citation styles (APA, IEEE, MLA, Chicago, etc.).
- Use reference management software (Zotero, EndNote, Mendeley, BibTeX).
- Evaluate ethical considerations and plagiarism detection techniques.

Course Contents:

- UNIT I: Introduction to Citation Management – Purpose of citations in research, Direct and indirect citations, Citation styles and their applications (APA, IEEE, MLA, Chicago)
- UNIT II: Reference Management Tools – Overview of citation software (Zotero, Mendeley, EndNote, BibTeX), Automating citation generation and bibliography creation, Integrating citation tools with MS Word, LaTeX, and Google Docs
- UNIT III: Plagiarism Detection & Academic Integrity – Understanding plagiarism (types and consequences), Tools for plagiarism detection (Turnitin, iThenticate, Grammarly), Ethical guidelines for referencing and attribution
- UNIT IV: Managing and Organizing References – Creating and maintaining a reference library, Importing and exporting references, Collaboration and cloud-based reference sharing
- UNIT V: Advanced Citation Practices & Open Access Publishing – Digital Object Identifiers (DOI) and ORCID for researcher identification, Open-access journals and research repositories, Copyright and fair use policies
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Lipson, C. *Cite Right: A Quick Guide to Citation Styles*. University of Chicago Press.
2. Neville, C. *The Complete Guide to Referencing and Avoiding Plagiarism*. Open University Press.
3. Weller, M. *The Digital Scholar: How Technology Is Transforming Scholarly Practice*. Bloomsbury Academic.
4. Manuals of major citation styles (APA, IEEE, MLA, Chicago) and online resources from Purdue OWL and Elsevier.

ITR03: Techniques of research writing
Marks: 100 | Duration: 60 Hrs

Course Objectives:
- To develop academic writing skills for research papers, reports, and dissertations.
- To explore structuring and formatting techniques for scientific writing.
- To analyze common writing challenges and strategies for improving clarity.
- To provide hands-on training on writing tools and editing software.

Course Learning Outcomes:
- Understand the structure and components of academic research writing.
- Develop clear, concise, and well-structured research documents.
- Apply writing techniques for abstracts, introductions, and discussions.
- Use writing and editing tools (Grammarly, LaTeX, MS Word, Overleaf).

Course Contents:
- UNIT I: Introduction to Research Writing – Importance of clarity and coherence in research writing, Types of academic writing (journal articles, conference papers, dissertations), Writing styles and conventions
- UNIT II: Structuring a Research Paper or Thesis – Title, abstract, and keywords, Introduction, literature review, methodology, results, discussion, conclusion, References and appendices
- UNIT III: Academic Writing Best Practices – Sentence structure, grammar, and punctuation, Avoiding redundancy and ambiguity, Writing for different audiences (academic, industry, policymakers)
- UNIT IV: Research Writing Tools & Technologies – Reference managers (Zotero, EndNote), Writing platforms (MS Word, LaTeX, Overleaf), AI-assisted writing tools (Grammarly, Hemingway Editor)
- UNIT V: Publishing & Presenting Research – Preparing research papers for journals and conferences, Writing grant proposals and research funding applications, Oral and poster presentations
- The course includes tutorials/case studies/hands-on exercises to enhance practical understanding and application.

Recommended Readings:

1. Booth, W. C., Colomb, G. G., Williams, J. M. *The Craft of Research*. University of Chicago Press.
2. Day, R. A. *How to Write and Publish a Scientific Paper*. Cambridge University Press.
3. Alley, M. *The Craft of Scientific Writing*. Springer.
4. Resources from Nature, Elsevier, and IEEE Author Guidelines on research writing best practices.