Appendix-22
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INDEX
DEPARTMENT OF PHYSICS AND ASTROPHYSICS
Semester-VI

B. SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC - 16: STATISTICAL MECHANICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Statistical Mechanics DSC – 16	4	4	0	0	Appeared in Semester 5	--

LEARNING OBJECTIVES

Statistical mechanics deals with the derivation of the macroscopic parameters (internal energy, pressure, specific heat etc.) of a physical system consisting of large number of particles (solid, liquid or gas) from knowledge of the underlying microscopic behaviour of atoms and molecules that comprises it. The main objective of this course work is to introduce the techniques of statistical mechanics which has applications in various fields including astrophysics, semiconductor physics, plasma physics, bio-physics etc. and in many other directions.

LEARNING OUTCOMES

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

- Understand the concepts of microstate, macrostate, phase space, thermodynamic probability and partition function.
- Understand the use of thermodynamic probability and partition function for calculation of thermodynamic properties for physical systems (ideal gas, finite level system)
- Understand the difference between the classical and quantum statistics and their applicability.
- Understand the properties and laws associated with thermal radiation.
- Apply the Fermi-Dirac distribution to model problems such as electrons in solids and white dwarf stars
- Apply the Bose-Einstein distribution to model problems such as black-body radiation and liquid helium.

SYLLABUS OF DSC – 16

THEORY COMPONENT

Unit - I **(26 Hours)**

Classical Statistics: Phase space, microstates and macrostates, entropy and thermodynamic probability, concept of ensemble - Introduction to three types, Maxwell-Boltzmann distribution law, partition function, thermodynamic functions of an ideal gas, Gibbs paradox, Sackur-

Tetrode equation; Saha's theory of thermal ionization (derivation not required); law of equipartition of energy (with proof) – Applications to specific heat of gases (monoatomic and diatomic) and solids and its limitations, thermodynamic functions of a finite level system, negative temperature.

Unit – II **(12 Hours)**
Bose-Einstein Statistics: Bose-Einstein distribution law, thermodynamic functions of a strongly degenerate Bose gas (non-relativistic), Bose-Einstein condensation, properties of liquid He (qualitative description), radiation as a photon gas and thermodynamic functions of photon gas; Bose derivation of Planck's law.

Unit – III **(12 Hours)**
Fermi-Dirac Statistics: Fermi-Dirac distribution law, thermodynamic functions of a completely and strongly degenerate Fermions (non-relativistic), specific heat of metals, relativistic Fermi gas, illustration with white dwarf star as an example, Chandrasekhar mass limit

Unit – IV **(10 Hours)**
Radiation: Blackbody radiation and its spectral distribution. Kirchhoff law (no proof), Planck's quantum postulates, Planck's law of blackbody radiation, deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan-Boltzmann law and Wien's displacement law from Planck's law, ultraviolet catastrophe.

The understanding of the topics in each of the four units mentioned above should be supported by solving sufficient number of problems related to the topics

References:
Essential Readings:
1) Statistical Mechanics, R. K. Pathria and P. D. Beale, Academic Press
2) Introductory Statistical Mechanics, R. Bowley and M. Sanchez, Oxford Univ. Press
3) Statistical Physics, F. Mandl, Wiley
4) A treatise on Heat, M. N. Saha and B. N. Srivastava, Indian Press
5) Problems and Solutions on Thermodynamics and Statistical Mechanics, Lim Yung-Kou, Sarat Book House
6) An Introduction to Thermal Physics, D. Schroeder, Pearson
7) Statistical Physics, Berkeley Physics Course, F. Reif, McGraw-Hill

Additional Readings:
1) An Introduction to Statistical Physics, W. G. V. Rosser, Wiley
2) Thermal Physics, Kittel and Kroemer, CBS
3) Concepts in Thermal Physics, Blundell and Blundell, Oxford University Press
4) Statistical and Thermal Physics, Loknathan and Gambhir, PHI
5) Thermodynamics, Kinetic theory and Statistical thermodynamics, Sears and Salinger, PHI
6) Statistical Mechanics, G. Sanon, Narosa Publishers

DISCIPLINE SPECIFIC CORE COURSE – DSC - 17: ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Atomic, Molecular and Nuclear Physics DSC – 17	**4**	**4**	**0**	**0**	Appeared in Semester 5	Light and Matter, Modern Physics and Quantum Mechanics-I of this course or their equivalent

LEARNING OBJECTIVES

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

LEARNING OUTCOMES

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

- Stern-Gerlach experiment, electron spin, spin magnetic moments, space quantization and Zeeman effect, spectral notations for atomic and molecular states and corresponding term symbols, understanding of atomic spectra and molecular spectra
- Basic principle of Raman spectroscopy and Franck Condon principle.
- The radioactive processes and the stability of the nuclei, the nuclear models and the nuclear reactions like fission and fusion useful in nuclear reactors.
- The full scientific potential lies on how we are able to interpret the fundamental astrophysical and nuclear data. The acquired knowledge can be applied in the areas of astrophysics, nuclear, medical, geology and other interdisciplinary fields of Physics, Chemistry and Biology. It will enhance the special skills required for these fields

SYLLABUS OF DSC - 17

THEORY COMPONENT

Unit – I - Atomic Physics **(20 Hours)**

One-electron atoms: Degeneracy of energy levels and selection rules, modes of relaxation of an excited atomic state.

Fine structure of Hydrogenic atoms: Shifting of energy levels, Splitting of spectral lines,

relativistic correction to kinetic energy, spin-orbit term, Darwin term, fine structure spectral lines, Lamb shift (qualitative idea).
Atoms in external magnetic fields: Larmor's theorem, Stern-Gerlach experiment, normal Zeeman Effect, Paschen Back effect, anomalous Zeeman effect, Lande g-factor.
Two and multi-electron systems: Spin multiplicity, singlet and triplet states and selection rules in helium atom spectra, Central field approximation, Aufbau and Pauli exclusion principle, Slater determinant, LS and JJ coupling scheme (equivalent and non-equivalent electrons), term symbols and Hund's rule. Lande' interval rule, Auger effect (qualitative idea)

Unit - II – Molecular Physics (16 Hours)

Molecular structure: The Born-Oppenheimer approximation, Concept of bonding and anti-bonding molecular orbitals, Concept of Potential energy curve for a diatomic molecule, Morse potential, Classification of molecular states of diatomic molecule, The Franck-Condon principle
Molecular spectra of diatomic molecule: Rotational Spectra (rigid and non-rigid rotor), Vibrational Spectra (harmonic and anharmonic), Vibration-Rotation Spectrum of a diatomic molecule, Isotope effect, Intensity of spectral lines
Raman Effect: Classical theory (with derivation) of Raman effect, pure rotational Raman Lines, Stoke's and Anti-Stoke's Lines, comparison with Rayleigh scattering.
Idea of spin resonance spectroscopy (NMR, ESR) with few examples

Unit – III – Nuclear Physics (24 Hours)

Radioactivity: Exponential decay law, isotope production, secular and transient equilibrium, forms of radioactivity
Nucleus stability: *Alpha decay:* Energetics of alpha-particle decay, barrier penetration model, Geiger-Nuttall rule, α- decay spectroscopy, decay Chains. *Beta Decay:* Q-values for beta decay, β-spectrum, positron emission, electron capture, neutrino hypothesis, Qualitative idea about Fermi theory, Fermi and Gamow-Teller decays, the role of angular momentum and parity, electron capture, and selection rules. *Gamma decay:* Gamma-ray production, and multipolarities, Weisskopf estimates, the role of angular momentum and parity, internal conversion.
Nuclear models: Evidence of shell structure in nuclei, Magic numbers, nuclear mean field, single particle shell model, spin-orbit splitting, shell model configurations for nuclear ground states, and low-lying excited levels
Nuclear reactions: Types of nuclear reactions (direct, compound), the center of mass frame, Q-values and threshold energies, compound nuclear reactions, resonance reactions. Thermonuclear reaction, Fusion, Fission barriers, physics of fission, energy release and partitioning in fission, neutron-induced fission, chain reaction, nuclear reactors.

References:

Essential Readings:

1) Physics of Atoms and Molecules, B. H. Bransden and C. J. Jochain, 2nd edition, Pearson
2) Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, 1994, Tata McGraw – Hill
3) Atomic physics, J. B. Rajam and foreword by Louis De Broglie, 2010, S. Chand & Co.
4) Atoms, Molecules and Photons, W. Demtroder, 2nd edition, 2010, Springer
5) Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman, G. A. Kriz and J. R. Vyvyan, 5th edition, 2014, Brookes/Cole
6) Concept of Nuclear Physics, B. L. Cohen, 2003, Tata McGraw – Hill

7) Nuclear Physics, S. N. Ghoshal, 1st edition, 2019, S. Chand Publication
8) Introducing Nuclear Physics, K. S. Krane, 2008, Wiley India

Additional Readings:

1) Basic Atomic and Molecular Spectroscopy, J. M. Hollas, Royal Society of Chemistry
2) Molecular Spectra and Molecular Structure, G. Herzberg
3) Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach (Series in Fundamental and Applied Nuclear Physics), K. Heyde (Institute of Physics Publishing 3rd edition
4) Nuclear Physics: principles and applications, John Lilley, 2006, Wiley
5) Schaum's Outline of Modern Physics, 1999, McGraw-Hill Education
6) Introduction to elementary particles, D. J. Griffiths, 2008, Wiley
7) Atomic and molecular Physics, R. Kumar, 2013, Campus Book Int.
8) The Fundamentals of Atomic and Molecular Physics (Undergraduate Lecture Notes in Physics), 2013, Springer

DISCIPLINE SPECIFIC CORE COURSE – DSC - 18: STATISTICAL ANALYSIS IN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Statistical Analysis in Physics DSC – 18	4	2	0	2	Appeared in Semester 5	Basic understanding of statistics and probability

LEARNING OBJECTIVES

This course provides an elementary introduction to the principles of Bayesian statistics and working knowledge of some of the data analysis techniques. The objective is to equip the students with certain techniques so that they may successfully apply these to the real world problems, in their research areas as well as in industry.

LEARNING OUTCOMES

After completing this course, students will be able to,

- Understand the fundamental concepts in statistical data analysis.
- Define in a Bayesian context, the likelihood, prior and posterior distributions and their role in Bayesian inference and hypothesis testing.
- Estimate the parameters of a distribution from sample.
- Perform hypothesis testing and validate a model.
- Apply multi-linear and logistic models to real life situation.

In the practical component, students will be able to

- Learn basic data analysis techniques such as linear and non-linear fittings
- Apply hypothesis testing techniques in physics
- Perform multi-linear and logistic regression analysis for a given data
- Understand the concept of gradient descent and use it for the regression analysis
- Understand the stochastic processes, Markov chains and transition probability matrix.

SYLLABUS OF DSC - 18

THEORY COMPONENT

Unit – I **(8 Hours)**

Random variables, Discrete and Continuous Probability Distributions. Bivariate and multivariate random variables, Joint Distribution Functions (with examples from Binomial, Poisson and Normal). Mean, variance and moments of a random vector, covariance and correlation matrix, eigendecomposition of the covariance matrix (bivariate problem). Cumulative Distribution Function and Quantiles. Point Estimation, Interval estimation, Central Limit Theorem (statement, consequences and limitations).

Unit – II **(11 Hours)**
Bayesian Statistics: Conditional probability and Bayes Theorem, Prior and Posterior probability distributions, examples of Bayes theorem in everyday life. Bayesian parameter estimation. Normal, Poisson and Binomial distributions, their conjugate priors and properties. Bayes factors and model selection.

Unit – III **(11 Hours)**
Bayesian Regression: Introduction to Bayesian Linear Regression. Bayesian logistic regression and its applications. Bayesian parameter estimation for regression models. Posterior distribution of model parameters and the posterior predictive distributions.

References:
Essential Readings:
1) Schaum's Outline Series of Probability and Statistics, M. R. Spiegel, J. J. Schiler and R. A. Srinivasan, 2012, McGraw Hill Education
2) Schaum's Outline Series of Theory and Problems of Probability, Random Variables, and Random Processes, H. Hsu, 2019, McGraw Hill Education
3) Bayesian Logical Data Analysis for the Physical Sciences: A Comparative Approach with Mathematica Support, P. Gregory, 2010, Cambridge University Press
4) Linear Regression: An Introduction to Statistical Models, P. Martin, 2021, Sage Publications Ltd.
5) Data Analysis: A Bayesian Tutorial, D. S. Sivia and J. Skilling, 2006, Oxford University Press
6) Data Reduction and Error analysis for the Physical Sciences, P. R. Bevington and D. K. Robinson, 2002, McGraw-Hill Education

Additional Readings:
1) A Guide to the Use of Statistical Methods in the Physical Sciences, R. J. Barlow, 1993, Wiley Publication
2) An Introduction to Error Analysis, J. R. Taylor, 1996, Univ. Sci. Books
3) Applied Multivariate Data Analysis, Volume I: Regression and Experimental Design, J. D. Jobson, 2012, Springer-Verlag
4) Statistical Rethinking A Bayesian Course with Examples in R and STAN, Richard McElreath, 2020, CRC Press
5) Introduction to Bayesian Statistics, W. Bolstad, 2007, John Wiley

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

The objective of this lab is to familiarise the students with the techniques of data analysis. The instructors are required to discuss the concepts and the pseudo-codes of the recommended programs in the practical sessions before their implementation. The implementation can be in any programming language. Inbuilt libraries can be used wherever applicable. **All units are mandatory.**

Unit 1 (12 Hours)
Probability Distributions
1) Generate sequences of N random numbers M (at least 10000) number of times from

different distributions (e.g. Binomial, Poisson, Normal). Use the arithmetic mean of each random vector (of size *N*) and plot the distribution of the arithmetic means. Verify the Central Limit Theorem (CLT) for each distribution. Show that CLT is violated for the Cauchy-Lorentz distribution.

2) Given a data for two independent variables (x_i, y_i). Write a code to compute the joint probability in a given sample space. Verify the same for the data generated by random number generator based on a given probability distribution of pair of independent variables (both discrete and continuous).

Unit 2 (16 Hours)

1) Hypothesis testing
   Make a random number generator to simulate the tossing of a coin n times with the probability for the head being q. Write a code for a Binomial test with the Null hypothesis H_0 ($q = 0.5$) against the alternative hypothesis H_1 ($q \neq 0.5$).

2) Bayesian Inference
   a) In an experiment of flipping a coin *N* times, *M* heads showed up (fraction of heads $f = M/N$). Write a code to determine the posterior probability, given the following prior for the probability of f:
      i. Beta Distribution $B(a, b)$ with given values of a and b .
      ii. Gaussian Distribution with a given mean and variance.
   b) Using the Likelihood of Binomial distribution, determine the value of f (fraction of heads) that maximizes the probability of the data.
   c) Plot the Likelihood (normalised), Prior and Posterior Distributions.

Unit 3 (20 hours)

Regression Analysis and Gradient Descent:

1) Given a dataset (*Xi, Yi*). Write a code to obtain the parameters of linear regression equation using the method of least squares with both constant and variable errors in the dependent variable (*Y*). The data obtained in a physics lab may be used for this purpose. Also obtain the correlation coefficient and the 90% confidence interval for the regression line. Make a scatter plot along with error bars. Also, overlay the regression line and show the confidence interval.

2) Write a code to minimize the cost function (mean squared error) in the linear regression using gradient descent (an iterative optimization algorithm, which finds the minimum of a differentiable function) with at least two independent variables. Determine the correlation matrix for the regression parameters.

3) Write a code to map a random variable *X* that can take a wide range of values to another variable *Y* with values lying in limited interval say [0, 1] using a sigmoid function (logistic function). Considering the Log Loss as the cost function of logistic regression, compute its minimum with gradient descent method and estimate the parameters.

Unit 4 (12 Hours)

Markov Chain (Any one)

1) Write a code to generate a Markov chain by defining (a finite number of) *M* (say 2) states. Encode states using a number and assign their probabilities for changing from state i to

state j. Compute the transition matrix for $1, 2,\ldots, N$ steps. Following the rule, write a code for Markovian Brownian motion of a particle.

2) Given that a particle may exist in one of the given energy states (E_i, $i = 1, \ldots 4$) and the transition probability matrix T, so that T_{ij} gives the probability for the particle to make transition from energy state E_i to state E_j. Determine the long-term probability of a particle to be in state in the state E_f if the particle was initially in state E_i.

References for laboratory work:

1) Data Science from Scratch – First Principles with Python, J. Grus, O'Reilly, 2019, Media Inc.
2) Bayes' Rule with Python: A tutorial introduction to Bayesian Analysis, J. V. Stone, 2016, Sebtel Press
3) Practical Bayesian Inference, B. Jones, 2017, Cambridge University Press
4) Modeling and Simulation in Scilab/Scicos with Scicos Lab 4.4, S. L. Campbell, Jean-P. Chancelier and R. Nikoukhah, Springer.
5) Scilab Textbook Companion for Probability And Statistics For Engineers And Scientists, S. M. Ross, 2005, Elsevier
6) Numerical Recipes: The art of scientific computing, W. H. Press, S. A. Teukolsky and W. Vetterling, 2007, Cambridge University Press

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

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Advanced Mathematical Physics II DSE – 9	4	4	0	0	Appeared in Semester 5	DSC Mathematical Physics-I and Mathematical Physics-II of this course or their equivalent

LEARNING OBJECTIVES

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

LEARNING OUTCOMES

After completing this course, student will,

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

SYLLABUS OF DSE - 9

THEORY COMPONENT

Unit - I **(12 Hours)**

Cartesian Tensors: Transformation of co-ordinates under rotation of axes. Einstein's Summation Convention; relation between direction cosines; transformation law for a tensor of rank n. Sum, inner product and outer product of tensors, contraction of tensors, quotient law of tensors, symmetric and anti-symmetric tensors; invariant tensors (Kronecker and alternating tensor); association of anti-symmetric tensor of rank two with vectors; vector algebra and calculus in tensor notation; differentiation, gradient, divergence and curl of tensor fields; vector identities in tensor notation.

Unit - II **(12 hours)**
Applications of Cartesian Tensors: Equation of a line, angle between lines, projection of a line on another line, condition for two lines to be coplanar and length and foot of the perpendicular from a point on a line; rotation tensor and its properties.
Moment of Inertia Tensor, Stress and Strain Tensors, Elasticity Tensor, Generalized Hooke's Law, Electric Polarizability Tensor.

Unit - III **(18 hours)**
General Tensors: Transformation of co-ordinates and contravariant and covariant vectors. Transformation law for contravariant, covariant and mixed tensors. Kronecker Delta and permutation tensors. Algebra of general tensors. Quotient law general tensors. Symmetric and anti-symmetric tensors. Metric tensor. Reciprocal tensors. Associated tensors. Christoffel symbols of first and second kind and their transformation laws. Covariant derivative, gradient, divergence and curl of tensor fields.

Unit - IV **(18 hours)**
Covariant Formulation of Electrodynamics: Minkowski space, four vectors (four-displacement, four-velocity, four-momentum, four-vector potential, four-current density,). tensorial form of Lorentz transformation. Electromagnetic field-strength tensor, Four rank permutation tensor, dual field-strength tensor, Lorentz transformation of electric and magnetic fields, electromagnetic field tensor, covariance of Maxwell's Equations.

References:
Essential Readings:
1) Vector Analysis and Cartesian Tensors, 3rd edition, D. E. Bourne, P. C. Kendall, 1992
2) Cartesian Tensors, H. Jeffreys, 1931, Cambridge University Press.
3) Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, 2010, Elsevier.
4) A Brief on Tensor Analysis, J. G. Simmonds, 1997, Springer.
5) Schaum's outlines series on Vector Analysis, M. Spiegel, 2nd edition, 2017.
6) Schaum's Outline Series on Tensor Calculus, D. Kay, Revised 1st edition, 2011.
7) An Introduction to Tensor Calculus and Relativity, D. F. Lawden, 2013, Literary Licensing

Additional Readings:
1) A Student's Guide to Vectors and Tensors, Daniel A. Fleisch, 2011, Cambridge Univ. Press.
2) Matrices and tensors in physics by A. W. Joshi, 1995, New Age International Publications.
3) The Feynman Lectures on Physics, Volume II, Feynman, Leighton and Sands, 2008, Narosa Publishing House.
4) Classical Electrodynamics, J. D. Jackson, 3rd edition, 2009, Wiley Publication.
5) A Primer in Tensor Analysis and Relativity, I. L. Shapiro, 1st edition, 2019, Springer.
6) Gravity-An introduction to Einstein's General Relativity, J. B. Hartle, 2009, Pearson Education.
7) A first course in general relativity, B. F. Schutz, 2004, Cambridge University Press.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 10: MICROPROCESSOR

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Microprocessor DSE – 10	4	2	0	2	Appeared in Semester 5	--

LEARNING OBJECTIVES

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

LEARNING OUTCOMES

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

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

SYLLABUS OF DSE - 10

THEORY COMPONENT

Unit – I - Introduction to 8085 Microprocessor Architecture (16 Hours)

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

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

Unit – II - 8085 Programming (14 Hours)

Operation code, operand and mnemonics, instruction set of 8085, instruction classification, addressing modes, instruction format, data transfer instructions, arithmetic instructions, increment & decrement instructions, logical instructions, branch instructions and machine control instructions, subroutine, call and return instructions, timing diagrams-instruction cycle, machine cycle, T- states, basic idea of interrupts, assembly language programming examples (addition with and without carry, subtraction with and without borrow, double addition, multiplication by repeated addition, division by repeated subtraction, block data transfer and checking of parity of a binary number)

References:

Essential Readings:

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

Additional Readings:

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

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

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

8085 Assembly language programs

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

References for laboratory work:

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 11: RESEARCH METHODOLOGY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Research Methodology DSE – 11	4	3	0	1	Appeared in Semester 5	--

LEARNING OBJECTIVES

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

LEARNING OUTCOMES

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

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

SYLLABUS OF DSE - 11

THEORY COMPONENT

Unit - I - Introduction to research methodology (6 Hours)

Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey (open-source and paid tools for keeping track of the literature)

Unit - II - Data collection, analysis and interpretation (15 Hours)

Methods of data collection: survey, interview, observation, experimentation and case study;
Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation);
Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of multiple linear regression analysis and theory of attributes);
Curve fitting using linear and nonlinear regression (parameter space, gradient search method and Marquardt method);
Role of simulation, calibration methods, error analysis, and background handling in experimental design

Unit - III – Journals, Database and Research Metrics **(7 Hours)**

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

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

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

Unit - IV – Scientific Conduct and Publication Ethics **(8 Hours)**

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

COPE guidelines on best practices in publication ethics

Unit V – Scientific Writing and Software Tools **(5 Hours)**

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

Referencing formats (APA, MLA) and bibliography management

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

Unit VI - Intellectual Property Right and Research Funding **(4 Hours)**

Basic concepts and types of intellectual property (patent, copyright and trademark)

Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

References:

Essential Readings:

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

Additional Readings:

1) Research Methods, R. Ahuja, 2001, Rawat Publications, New Delhi.
2) Research design: Qualitative, quantitative, and mixed methods approaches, J. W. Creswell, and J. D. Creswell, 2017, Sage Publications.

3) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, A. R. Miller and M. H. Davis, 2000, West Group Publishers

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

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

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Category II

Physical Science Courses
with Physics discipline as one of the Core Disciplines

(B. Sc. Physical Science with Physics as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 6: SOLID STATE PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Solid State Physics PHYSICS DSC – 6	4	2	0	2	Appeared in Semester 5	Understanding of basic concepts of Physics

LEARNING OBJECTIVES

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. It also communicates the importance of solid state physics in modern society.

LEARNING OUTCOMES

On successful completion of the module students should be able to,

- Elucidate the concept of lattice, crystals and its planes
- Understand the elementary lattice dynamics and its influence on the properties of materials
- Understanding about origin of energy bands, and their influence on electronic behaviour
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

SYLLABUS OF PHYSICS DSC – 6

THEORY COMPONENT

Unit – I - Crystal Structure (10 Hours)

Solids: amorphous and crystalline materials, lattice translation vectors, lattice with a basis, unit cell, types of lattices, Miller indices, reciprocal lattice, Ewald's construction (geometrical approach), Brillouin zones, diffraction of X-rays by crystals. Bragg's law

Unit – II - Elementary Lattice Dynamics (6 Hours)

Lattice vibrations and phonons: linear monoatomic and diatomic chains, acoustical and optical phonons, Dulong and Petit's law, qualitative discussion of Einstein and Debye theories, T^3 law.

Unit – III - Elementary Band Theory **(5 Hours)**
Qualitative understanding of Kronig and Penny model (without derivation) and formation of bands in solids, concept of effective mass, Hall effect in semiconductor, Hall coefficient, application of Hall Effect, basic introduction to superconductivity

Unit – IV - Magnetic Properties of Matter **(6 Hours)**
dia-, para-, and ferro- magnetic materials, classical Langevin theory of dia– and para-magnetism (no quantum mechanical treatment), qualitative discussion about Weiss's theory of ferromagnetism and formation of ferromagnetic domains, B-H curve hysteresis and energy loss

Unit – V - Dielectric Properties of Materials **(3 Hours)**
Polarization, local electric field in solids, electric susceptibility, polarizability, Clausius Mossoti equation, qualitative discussion about ferroelectricity and PE hysteresis loop

References:
Essential Readings:

1) Introduction to Solid State Physics, C. Kittel, 8th edition, 2004, Wiley India Pvt. Ltd.
2) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
3) Introduction to Solids, L. V. Azaroff, 2004, Tata Mc-Graw Hill
4) Solid State Physics, N. W. Ashcroft and N. D. Mermin, 1976, Cengage Learning
5) Solid State Physics, M. A. Wahab, 2011, Narosa Publications

Additional Readings:

1) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
2) Solid State Physics, R. John, 2014, McGraw Hill
3) Superconductivity: A very short introduction, S. J. Blundell, Audiobook

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Measurement of susceptibility of paramagnetic solution (Quinck's tube method)
2) To measure the magnetic susceptibility of solids
3) To determine the coupling coefficient of a piezoelectric crystal
4) To study the dielectric response of materials with frequency
5) To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique
6) To determine the refractive index of a dielectric layer using SPR technique
7) To study the PE Hysteresis loop of a ferroelectric crystal
8) To draw the BH curve of iron (Fe) using a Solenoid and determine the energy loss from hysteresis loop
9) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150^{o} C) by four-probe method and determine its band gap
10) To determine the Hall coefficient of a semiconductor sample

11) Analysis of X-ray diffraction data in terms of unit cell parameters and estimation of particle size
12) Measurement of change in resistance of a semiconductor with magnetic field.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
3) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
4) An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5) Practical Physics, G. L. Squires, 4th edition, 2015
6) Practical Physics, C. L. Arora, 19th edition, 2015, S. Chand

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16a: MATHEMATICAL PHYSICS II

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Mathematical Physics II PHYSICS DSE 16a	4	4	0	0	Appeared in Semester 5	Mathematics as Discipline Specific Core course containing linear algebra and calculus.

LEARNING OBJECTIVES

The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists. The mathematical tools might be building blocks to understand the fundamental computational physics skills and hence enable them to solve a wide range of physics problems. Overall, to help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will be able to,

- Understand algebraic structures in n-dimension and basic properties of the linear vector spaces.
- Apply vector spaces and matrices in the quantum world.
- Learn basic notions of calculus of variations.
- Learn Lagrangian and Hamiltonian of the physical system.
- Learn Fourier Transforms (FTs) and Laplace Transforms (LTs).
- Understand the applications of Fourier Transforms (FTs) and Laplace Transforms (LTs).

SYLLABUS OF PHYSICS DSE – 16a

THEORY COMPONENT

Unit – I **(18 Hours)**

Linear Algebra: Linear vector spaces, inner product of vectors and norm of a vector, Euclidean spaces, unitary spaces and inner product spaces. Properties of inner product spaces, Cauchy-Schwartz inequality, concept of length and distance, metric spaces. Orthogonality of vectors, orthonormal basis. Eigenvalue and Eigenvector, Adjoint of a linear operator, Hermitian or Self adjoint operators and their properties and Unitary Operators. Hilbert Space (Definition Only).

Unit – II **(18 Hours)**
Calculus of Variations: Variable Calculus: Variational Principle, Euler's Equation and its Application to Simple Problems. Geodesics. Concept of Lagrangian. Generalized co-ordinates. Euler-Lagrange's Equations of Motion and its Applications to Simple Problems (e.g., Simple Pendulum and One dimensional harmonic oscillator)

Unit – III **(10 Hours)**
Fourier Transforms (FTs): Fourier Integral Theorem. Sine and Cosine Transforms. Properties of FTs: (1) FTs of Derivatives of Functions, (2) Change of Scale Theorem, (3) FTs of Complex Conjugates of Functions, (4) Shifting Theorem, (5) Modulation Theorem, (6) Convolution Theorems, and (7) Parseval's Identity.

Unit – IV **(9 Hours)**
Laplace Transforms (LTs): Existence Theorem. LTs of elementary functions. Properties of LTs: (1) Change of scale theorem, (2) Shifting theorem, (3) LTs of derivatives and integrals of functions, (4) Derivatives and integrals of LTs, (5) LT of unit step function, (6) LTs of periodic functions, and (6) Convolution theorem. Inverse LT

Unit – V **(5 Hours)**
Applications of Integral Transforms: (1) Solution of first and second order ODEs by using FTs (2) Solution of first and second order ODEs by using LTs (3) Solution of simultaneous first order ODEs by using LTs,

References:
Essential Readings:
1) Mathematical Tools for Physics, J. Nearing, 2010, Dover Publications
2) Theory and Problems of Linear Algebra, S. Lipschutz, 1987, McGraco-Hill Inc.
3) Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, 2010, Elsevier.
4) Mathematical Methods for Physicists: A Concise Introduction: T. L. Chow, 2000, Cambridge Univ. Press.
5) Introduction to Matrices & Linear Transformations, D. T. Finkbeiner, 1978, Dover Pub.
6) Matrices and tensors in Physics: A.W. Joshi, 2017, New Age International Pvt.
7) Mathematical Methods in the Physical Sciences, M. L. Boas, 3rd edition, 2007, Wiley India.
8) Advanced Engineering Mathematics, E. Kreyszig, 2008, Wiley India.

Additional Readings:
1) Elementary Linear Algebra, Applications Version, H. Anton and C. Rorres, Wiley Student edition.
2) Mathematics for Physicists, S. M. Lea, 2004, Thomson Brooks/Cole
3) An Introduction to Linear Algebra and Tensors, M. A. Akivis, V. V. Goldberg, Richard and Silverman, 2012, Dover Publications

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16b: COMMUNICATION SYSTEM

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Communication System PHYSICS DSE – 16b	4	2	0	2	Appeared in Semester 5	--

LEARNING OBJECTIVES

This paper aims to describe the fundamental concepts of communication systems and communication techniques based on analog modulation, analog and digital pulse modulation. Communication and Navigation systems such as GPS and mobile telephony system are also introduced. This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

LEARNING OUTCOMES

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

- Understand fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- Gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- Gain an in-depth understanding of different concepts used in a satellite communication system.
- Study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- In the laboratory course, students will apply the theoretical concepts to gain hands-on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.

SYLLABUS OF PHYSICS DSE – 16b

THEORY COMPONENT

Unit – I - Electronic communication and analog modulation (8 Hours)

Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system, channels and base-band signals

Analog Modulation: Amplitude modulation, modulation index and frequency spectrum. Generation of AM (emitter modulation), amplitude demodulation (diode detector), Single sideband (SSB) systems, advantages of SSB transmission, frequency modulation (FM) and phase modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM.

Unit – II - Analog Pulse Modulation (4 Hours)
Sampling theorem, basic principles - PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing)

Unit – III - Digital Pulse Modulation (10 Hours)
Need for digital transmission, pulse code modulation, digital carrier modulation techniques, sampling, quantization and encoding, concept of amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK), and binary phase shift keying (BPSK)

Unit – IV - Satellite Communication and Mobile Telephony system (8 Hours)
Satellite communication: Need for satellite communication, geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), uplink and downlink, Ground and earth stations
Mobile Telephony System: Concept of cell sectoring and cell splitting, SIM number, IMEI number, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset.

References:
Essential Readings:

1) Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2) Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
3) Electronic Communication systems, G. Kennedy, 3rd edition, 1999, Tata McGraw Hill.
4) Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
5) Modern Digital and Analog Communication Systems, B. P. Lathi, 4th edition, 2011, Oxford University Press.
6) Communication Systems, S. Haykin, 2006, Wiley India
7) Wireless communications, A. Goldsmith, 2015, Cambridge University Press

Additional Readings:

1) Electronic Communication, L. Temes and M. Schultz, Schaum's Outline Series, Tata McGraw- Hill.
2) Electronic Communication Systems, G. Kennedy and B. Davis, Tata McGraw-Hill
3) Analog and Digital Communication Systems, M. J. Roden, Prentice Hall of India

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) To design an amplitude modulator using transistor
2) To design envelope detector for demodulation of AM signal
3) To study FM - generator and detector circuit
4) To study AM transmitter and receiver
5) To study FM transmitter and receiver

6) To study time division multiplexing (TDM)
7) To design pulse amplitude modulator using transistor.
8) To design pulse width modulator using 555 timer IC.
9) To design pulse position modulator using 555 timer IC
10) To study ASK, PSK and FSK modulators and demodulators

References for laboratory work:

1) Electronic Communication system, Blake, Cengage, 5th edition
2) Introduction to Communication systems, U. Madhow, 1st edition, 2018, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16c: LASER PHYSICS AND ITS APPLICATIONS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Laser Physics and its Applications PHYSICS DSE – 16c	4	2	0	2	Appeared in Semester 5	--

LEARNING OBJECTIVES

Laser physics is a branch of optics that covers the fundamental and applied aspects of laser science. Laser is an acronym for 'Light Amplification by Stimulated Emission of Radiation'. This radiation has some specific properties different from the common light. The main objective of this course is to introduce the basic principle of its production, its types, the different kinds and techniques of laser devices and applications of laser in various fields including research, high energy applications, medical applications, industrial applications, and nuclear science. Also to perform experiments and to measure some physical quantities based on the experiments using lasers.

LEARNING OUTCOMES

After completing this course, students should be able to,

- Understand the nature of interaction of radiation with matter in the form of absorption of light, spontaneous and stimulated emission of radiation.
- Understand the principle of laser action, including population inversion, metastable states, gain medium, optical pumping, feedback mechanism and threshold condition for laser beam generation
- Understand the various types of lasers such as three and four-level lasers
- Understand various characteristic properties of lasers and how they are utilized in different applications
- Know the importance of lasers in holography and in fibre optics
- Perform some experiments based on the laser technique and to be able to measure some quantities through these experiments

SYLLABUS OF PHYSICS DSE 16c

THEORY COMPONENT

Unit 1 – Introduction (12 Hours)

Planck's theory of radiation (qualitative idea), energy levels, absorption process, spontaneous and stimulated emission processes, theory of laser action, population inversion, Einstein's A and B coefficients of transition, optical pumping, optical amplification, threshold for laser oscillation, line shape function (various line broadening mechanisms: collisional broadening, natural broadening, Doppler broadening), coherence (temporal and spatial type, role of coherence in laser action), optical resonator (different configurations and stability condition)

Unit 2 – Types of Laser **(8 Hours)**
Doped insulator laser (Nd:YAG laser, Ruby laser)
Semiconductor lasers (GaAs laser): Energy bands and carrier distribution in semiconductors, absorption and emission in a semiconductor, optical gain, laser oscillation, threshold current density, power output
Gas lasers: He-Ne laser, noble gas ion laser, carbon dioxide laser

Unit 3 – Applications of Laser **(10 Hours)**
Properties of laser light: Mono-chromaticity, directionality, line width, beam coherence, intensity, focussing
Applications: Measurement of distance (interferometry method, beam modulation telemetry), Holography (basic principle, coherence, recording and reconstruction method, white light reflection hologram, application in microscopy and character recognition), medical applications, laser tweezers, high energy applications, industrial applications, laser induced nuclear fusion

References:
Essential Readings:

1) Laser Physics, M. Sargent, M. O. Scully and W. E. Lamb Jr., 1974, Western Press
2) Laser Physics and Spectroscopy, P. N. Ghosh, 2016, Levant Books, India
3) Lasers: Fundametnals and applications, K. Thyagarajan and A. K. Ghatak, 2010, Tata McGraw Hill
4) Optical systems and processes, J. Shamir, 2009, PHI Learning Pvt. Ltd.
5) Fundamental of optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand and Co. Publications
6) Optics, E. Hecht, 4th edition, 2014, Pearson Education
7) Laser applications, M. Ross, 1968, McGraw Hill

Additional Readings:

1) Physics for scientists and engineers with modern physics, Jewett and Serway, 2010, Cengage Learning
2) Optical Physics, A. Lispon, S. G. Lipson and H. Lipson, 4th edition, 1996, Cambridge University Press
3) Fibre optics through experiments, M. R. Shenoy, S. K. Khijwania, et.al. 2009, Viva Books
4) Industrial applications of lasers, J. F. Ready, 2nd edition, 1997, Academic Press
5) Semiconductor optoelectronics, J. Singh, 1995, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) To determine the wavelength and angular spread of laser light by using plane diffraction grating.
2) To determine the wavelength of laser source using diffraction of single slit.
3) To determine the wavelength of laser source using diffraction of double slits.

4) To determine the grating radial spacing of the compact disc by reflection using He-Ne or solid state laser.
5) To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
6) To find the polarization angle of laser light using polarizer and analyser
7) To measure the numerical aperture of an optical fibre
8) To study the variation of the bending loss in a multimode fibre
9) To study thermal expansion of quartz using laser
10) To study the characteristics of solid state laser

References for laboratory work:

1) Advanced Practical Physics for students: B. L. Flint and H. T. Worsnop, Asia Publishing
2) Optoelectronics: An introduction, 3rd edition, 1998, Pearson Education
3) Introduction to fibre optics, A. K. Ghatak and K. Thyagarajan, 1998, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16d: RESEARCH METHODOLOGY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Research Methodology PHYSICS DSE – 16d	4	3	0	1	Appeared in Semester 5	--

LEARNING OBJECTIVES

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

LEARNING OUTCOMES

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

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

SYLLABUS OF Physics DSE – 16d

THEORY COMPONENT

Unit - I - Introduction to research methodology (6 Hours)

Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey (open-source and paid tools for keeping track of the literature)

Unit - II - Data collection, analysis and interpretation (15 Hours)

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

Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of multiple linear regression analysis and theory of attributes);
Curve fitting using linear and nonlinear regression (parameter space, gradient search method and Marquardt method);
Role of simulation, calibration methods, error analysis, and background handling in experimental design

Unit - III – Journals, Database and Research Metrics (7 Hours)
Journals: Free, open source and paid journals, concept of peer reviewed journals, predatory and fake journals
Databases: Indexing databases; citation databases (Web of science, Scopus); experimental physics databases (astrophysics (ADS, NED, SIMBAD, VizieR), biophysics (PubMed), particle physics (INSPIRE, CDS), condensed matter physics (X-ray database))
Research Metrics: Journal impact factor, SNIP, SJR, IPP, cite score; metrics (h-index, g index, i10 index, altmetrics), variations in research metrics across various disciplines, other limitations of the research metrics and impact factors

Unit - IV – Scientific Conduct and Publication Ethics (8 Hours)
Current understanding of ethics; intellectual honesty and research integrity; communicating errors (erratum, correction and withdrawal); records and logs (maintaining records of samples, raw data, experimental protocols, observation logs, analysis calculations, and codes); scientific publication misconducts: plagiarism (concept, importance, methods and ways to detect and avoid plagiarism) and redundant publications (salami slicing, duplicate and overlapping publications, selective reporting and misrepresentation of data); environmental and other clearances (waste management, disposal of hazardous waste).
COPE guidelines on best practices in publication ethics

Unit V – Scientific Writing and Software Tools (5 Hours)
Writing a research paper and report: introduction, motivation, scientific problem, its methodology, any experimental set up, data analysis, discussion of results, conclusions
Referencing formats (APA, MLA) and bibliography management
Graphical software (open source, magic plot, gnu plot, origin); presentation tools (beamer)

Unit VI - Intellectual Property Right and Research Funding (4 Hours)
Basic concepts and types of intellectual property (patent, copyright and trademark)
Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

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

Entrepreneur Press

Additional Readings:

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

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)
Students should perform at least six practicals from the following list, such that all the units mentioned below are covered.

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

Category II

Physical Science Courses (with Electronics) with Physics and Electronics discipline as Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 10: SOLID STATE PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Solid State Physics PHYSICS DSC 10	4	2	0	2	Appeared in Semester 5	Understanding of basic concepts of Physics

LEARNING OBJECTIVES

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. It also communicates the importance of solid state physics in modern society.

LEARNING OUTCOMES

On successful completion of the module students should be able to,

- Elucidate the concept of lattice, crystals and its planes
- Understand the elementary lattice dynamics and its influence on the properties of materials
- Understanding about origin of energy bands, and their influence on electronic behaviour
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

SYLLABUS OF PHYSICS DSC – 10

THEORY COMPONENT

Unit – I - Crystal Structure **(10 Hours)**

Solids: amorphous and crystalline materials, lattice translation vectors, lattice with a basis, unit cell, types of lattices, Miller indices, reciprocal lattice, Ewald's construction (geometrical approach), Brillouin zones, diffraction of X-rays by crystals. Bragg's law

Unit – II - Elementary Lattice Dynamics **(6 Hours)**

Lattice vibrations and phonons: linear monoatomic and diatomic chains, acoustical and optical phonons, Dulong and Petit's law, qualitative discussion of Einstein and Debye theories, T^3 law.

Unit – III - Elementary Band Theory **(5 Hours)**
Qualitative understanding of Kronig and Penny model (without derivation) and formation of bands in solids, concept of effective mass, Hall effect in semiconductor, Hall coefficient, application of Hall effect, basic introduction to superconductivity

Unit – IV - Magnetic Properties of Matter **(6 Hours)**
dia-, para-, and ferro- magnetic materials, classical Langevin theory of dia– and para-magnetism (no quantum mechanical treatment), qualitative discussion about Weiss's theory of ferromagnetism and formation of ferromagnetic domains, B-H curve hysteresis and energy loss

Unit – V - Dielectric Properties of Materials **(3 Hours)**
Polarization, local electric field in solids, electric susceptibility, polarizability, Clausius Mossoti equation, qualitative discussion about ferroelectricity and PE hysteresis loop

References:
Essential Readings:

1) Introduction to Solid State Physics, C. Kittel, 8th edition, 2004, Wiley India Pvt. Ltd.
2) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
3) Introduction to Solids, L. V. Azaroff, 2004, Tata Mc-Graw Hill
4) Solid State Physics, N. W. Ashcroft and N. D. Mermin, 1976, Cengage Learning
5) Solid State Physics, M. A. Wahab, 2011, Narosa Publications

Additional Readings:

1) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
2) Solid State Physics, R. John, 2014, McGraw Hill
3) Superconductivity: A Very short Introduction – Stephen J Blundell - Audiobook

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Measurement of susceptibility of paramagnetic solution (Quinck's tube method)
2) To measure the magnetic susceptibility of solids
3) To determine the coupling coefficient of a piezoelectric crystal
4) To study the dielectric response of materials with frequency
5) To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique
6) To determine the refractive index of a dielectric layer using SPR technique
7) To study the PE Hysteresis loop of a ferroelectric crystal
8) To draw the BH curve of iron (Fe) using a solenoid and determine the energy loss from hysteresis loop
9) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150^{o} C) by four-probe method and determine its band gap
10) To determine the Hall coefficient of a semiconductor sample

11) Analysis of X-ray diffraction data in terms of unit cell parameters and estimation of particle size
12) Measurement of change in resistance of a semiconductor with magnetic field.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
3) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
4) An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5) Practical Physics, G. L. Squires, 4th edition, 2015
6) Practical Physics, C. L. Arora, 19th edition, 2015, S. Chand

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 13: RESEARCH METHODOLOGY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Research Methodology PHYSICS DSE 13	4	3	0	1	Appeared in Semester 5	--

LEARNING OBJECTIVES

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

LEARNING OUTCOMES

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

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

SYLLABUS OF Physics DSE - 13

THEORY COMPONENT

Unit - I - Introduction to research methodology (6 Hours)

Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey (open-source and paid tools for keeping track of the literature)

Unit - II - Data collection, analysis and interpretation (15 Hours)

Methods of data collection: survey, interview, observation, experimentation and case study;
Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation);
Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of

multiple linear regression analysis and theory of attributes);
Curve fitting using linear and nonlinear regression (parameter space, gradient search method and Marquardt method);
Role of simulation, calibration methods, error analysis, and background handling in experimental design

Unit - III – Journals, Database and Research Metrics (7 Hours)
Journals: Free, open source and paid journals, concept of peer reviewed journals, predatory and fake journals
Databases: Indexing databases; citation databases (Web of science, Scopus); experimental physics databases (astrophysics (ADS, NED, SIMBAD, VizieR), biophysics (PubMed), particle physics (INSPIRE, CDS), condensed matter physics (X-ray database))
Research Metrics: Journal impact factor, SNIP, SJR, IPP, cite score; metrics (h-index, g index, i10 index, altmetrics), variations in research metrics across various disciplines, other limitations of the research metrics and impact factors

Unit - IV – Scientific Conduct and Publication Ethics (8 Hours)
Current understanding of ethics; intellectual honesty and research integrity; communicating errors (erratum, correction and withdrawal); records and logs (maintaining records of samples, raw data, experimental protocols, observation logs, analysis calculations, and codes); scientific publication misconducts: plagiarism (concept, importance, methods and ways to detect and avoid plagiarism) and redundant publications (salami slicing, duplicate and overlapping publications, selective reporting and misrepresentation of data); environmental and other clearances (waste management, disposal of hazardous waste).
COPE guidelines on best practices in publication ethics

Unit V – Scientific Writing and Software Tools (5 Hours)
Writing a research paper and report: introduction, motivation, scientific problem, its methodology, any experimental set up, data analysis, discussion of results, conclusions
Referencing formats (APA, MLA) and bibliography management
Graphical software (open source, magic plot, gnu plot, origin); presentation tools (beamer)

Unit VI - Intellectual Property Right and Research Funding (4 Hours)
Basic concepts and types of intellectual property (patent, copyright and trademark)
Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

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

Additional Readings:

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

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)
Students should perform at least six practicals from the following list, such that all the units mentioned below are covered.

Unit 1:

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

Unit 2:

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

Unit 3:

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

Unit 4:

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

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 14: VERILOG AND FPGA BASED SYSTEM DESIGN

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Verilog and FPGA based System Design Physics DSE 14	4	2	0	2	Appeared in Semester 5	--

LEARNING OBJECTIVES

This course trains the students to use VLSI design methodologies and simulate simple digital systems. Students will understand the HDL design flow and the fundamental Verilog concepts in-lieu of today's most advanced digital design techniques. The emphasis of this course is to enhance the understanding of Programmable Logic Devices so as to implement the Digital Designs on FPGAs using Verilog HDL

LEARNING OUTCOMES

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

- Write synthesizable Verilog code.
- Write a Verilog test bench to test Digital Logic Design.
- Design and simulate digital circuits using Verilog modules.
- Understand various types of programmable logic building blocks such as PAL, PLA, CPLDs and FPGAs and their trade-offs.
- Design and implement digital systems on a programmable logic device FPGA using Verilog HDL.

SYLLABUS OF PHYSICS DSE 14

THEORY COMPONENT

Unit – I **(20 Hours)**

Introduction to Verilog: Introduction to HDL, importance of HDL, popularity of Verilog HDL, design flow, structure of HDL module, Verilog modules (design and stimulus), introduction to language elements - keywords, identifiers, white space, comments, format, integers, real and strings, logic values, data types, scalars and vector nets, parameters, system tasks, compiler directives

Gate level modelling: Introduction, built in primitive gates, buffers, multiple input gates, gate delays.

Data flow modelling: Continuous assignment, net declaration assignments, net delays, operator types and operators precedence

Behavioral modelling: Always and initial constructs, procedural assignment (blocking and non-blocking statements), If-else, case statements, loop structures (while, for, repeat and forever), sequential and parallel Blocks

Modelling of combinational and sequential digital circuits using different levels of abstraction Hierarchical modelling concepts: Design methodologies, design a 4-bit adder using four 1-bit full adders

Unit – II **(10 Hours)**

Look up Tables: 2-input, 3-input and 4-input LUTs, Implement logic functions with LUT, advantages and disadvantages of lookup tables

Programmable Logic Devices: Difference between PAL and PLA, Realize simple logic functions using PAL and PLA, CPLD and FPGA architectures, types of FPGA, logic cell structure, programmable interconnects, logic blocks and I/O Ports, placement and routing, applications of FPGAs

References:

Essential Readings:

1) Verilog HDL. Pearson Education, S. Palnitkar, 2nd edition, 2003
2) FPGA Based System Design. W. Wolf, Pearson Education
3) Digital Signal processing, S. K. Mitra, 1998, McGraw Hill
4) VLSI design, D. P. Das, 2nd edition, 2015, Oxford University Press.
5) Digital Signal Processing with FPGAs, U. Meyer Baese, Springer, 2004

Additional Readings:

1) Fundamentals of Digital Logic with Verilog Design, S. B. Zvonko Vranesic, 2016, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Session on how to write the design module and test benches using required software and simulate the combinational and sequential circuits.
- Sessions on how to configure FPGA using Verilog HDL for the final implementation of the logic design.

At least six experiments to be performed from the following list

1) Half adder, Full Adder using basic and derived gates.
2) Half subtractor and Full Subtractor using basic and derived gates.
3) Design and simulate 4-bit Adder using Data Flow Modeling.
4) Multiplexer (4x1) and Demultiplexer(1X4) using Data Flow Modeling.
5) Decoder and Encoder using case structure/gates.
6) Clocked D, JK and T Flip flops (with Reset inputs)
7) 4-bit Synchronous up/downCounter
8) To design and study switching circuits (LED blink shift)
9) To interface LCD using FPGA
10) To interface a multiplexed seven segment display.
11) To interface a stepper motor and DC motor.

References for laboratory work:

1) Digital System Designs and Practices: Using Verilog HDL and FPGAs, Ming-Bo Lin, Wiley India Pvt Ltd.
2) Verilog Digital System Design, Z. Navabi, 2^{nd} edition, TMH
3) Designing Digital Computer Systems with Verilog, D. J. Laja and S. Sapatnekar, 2015, Cambridge University Press
4) Verilog HDL primer, J. Bhasker. BSP, 2^{nd} edition, 2003

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15: PHOTONIC DEVICES AND POWER ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Photonic Devices and Power Electronics Physics DSE 15	4	2	0	2	Appeared in Semester 5	--

LEARNING OBJECTIVES

This paper aims to provide students with an in-depth understanding of the principles, concepts, and applications of photonic devices and power electronics. The course covers a range of topics, including, semiconductor lasers, fibre optics, power diodes, power MOSFETs, and power electronics applications. Students will develop the necessary knowledge and skills to design and analyse various photonic and power electronic devices and systems. The course also emphasizes the practical aspects of device design, fabrication, and characterization, preparing students for real-world challenges and opportunities in these fields.

LEARNING OUTCOMES

Upon completion of the course on Photonic Devices and Power Electronics, students are expected to achieve the following learning outcomes.

- Understand the basic principles and concepts of photonic devices and power electronics, including semiconductor lasers, fibre optics, power diodes, power MOSFETs, and power electronics applications.
- Develop the necessary knowledge and skills to design and analyse various photonic and power electronic devices and systems.
- Gain practical experience in device design, fabrication, and characterization.
- Apply the knowledge and skills learned in the course to real-world challenges and opportunities in the fields of photonics and power electronics.
- Develop problem-solving skills, critical thinking skills, and the ability to apply scientific and engineering principles to practical problems.
- Understand the ethical considerations and professional responsibilities associated with the development and use of photonic and power electronic devices and systems.
- Overall, students will gain a comprehensive understanding of photonic devices and power electronics and be well-equipped to pursue careers in these fields or continue their studies at the graduate level.

SYLLABUS OF PHYSICS DSE 15

THEORY COMPONENT

Unit – I **(4 Hours)**

Classification of photonic devices: Radiative transition and optical absorption. Light Emitting Diodes (Construction, materials and operation)

Semiconductor LASER: Condition for amplification, laser cavity, LASER diode.

Unit – II **(8 Hours)**

Photodetectors: Photoconductor, photodiodes (p-i-n, avalanche) and photo transistors, quantum efficiency and responsivity

Solar Cell: Construction, working and characteristics.

LCD Displays: Types of liquid crystals, Principle of Liquid Crystal Displays, applications, advantages over LED displays.

Unit – III **(4 Hours)**

Introduction to Fiber Optics: Element of an Optical Fiber Transmission link- Optical Fiber Modes and Configurations, Overview of Modes -Single Mode Fibers-Graded Index fiber structure.

Unit – IV **(8 Hours)**

Power Devices: Need for semiconductor power devices, Power MOSFET (qualitative); introduction to family of thyristors; Silicon Controlled Rectifier (SCR) - structure, I-V characteristics, Turn-On and Turn-Off characteristics, ratings, Gate-triggering circuits; DIAC and TRIAC- Basic structure, working and V-I characteristics

Insulated Gate Bipolar Transistors (IGBT): Basic structure, I-V Characteristics, switching characteristics, device limitations and safe operating area (SOA)

Unit – V **(6 Hours)**

Applications of SCR: Phase controlled rectification, AC voltage control using SCR and Triac as a switch. Power Invertors- Need for commutating circuits and their various types, dc link invertors, Parallel capacitor commutated invertors.

References:

Essential Readings:

1) Optoelectronics, J. Wilson and J. F. B. Hawkes, 1996, Prentice Hall India
2) Optoelectronics and Photonics, S. O. Kasap, 2009, Pearson Education
3) Electronic Devices and Circuits, D. A. Bell, 2015, Oxford University Press
4) Introduction to fibre optics, A. K. Ghatak and K. Thyagarajan, 1998, Cambridge University Press
5) Power Electronics, M. D. Singh and K. B. Khanchandani, Tata McGraw Hill.

Additional Readings:

1) Power Electronics, J. S. Chitode, Technical Publications
2) Basic Electrical and Electronics Engineering, R. Saravanakumar V. Jegathesan and K. V. Kumar, Wiley
3) Power Electronics: Essentials & Applications, L. Umanand, Wiley

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Diffraction experiments using a LASER.
2) To determine characteristics of (a) LEDs, (b) Photovoltaic cell and (c) Photodiode.
3) To study the Characteristics of LDR and Photodiode with (i) Variable Illumination intensity, and (ii) Linear Displacement of source.
4) To measure the numerical aperture of an optical fiber.
5) Output and transfer characteristics of a power MOSFET.
6) Study of I-V characteristics of SCR.
7) SCR as a half wave and full wave rectifier with R and R - L loads.
8) AC voltage controller using TRIAC with UJT triggering.
9) Study of I-V characteristics of DIAC.
10) Study of I-V characteristics of TRIAC

References for laboratory work:

1) Power Electronics, P. C. Sen, Tata McGraw Hill.
2) Power Electronics Circuits, Devices & Applications, 3rd edition, M. H. Rashid, Pearson Education
3) A Textbook of Electrical Technology, Vol-II, B. L. Thareja and A. K. Thareja, S. Chand.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16: ANTENNA THEORY AND WIRELESS NETWORK

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Antenna Theory and Wireless Network Physics DSE 16	4	2	0	2	Appeared in Semester 5	--

LEARNING OBJECTIVES

This course gives an overview of wireless communication elements and networks. Students will develop an understanding of basics of antenna, its various parameters, its usage as a transmitter and receiver. Cellular concept and system design fundamentals are described and the evolution of current wireless systems in real world such as 2G, 3G, 4G and LTE networks is discussed.

LEARNING OUTCOMES

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

- Identify basic antenna parameter (radiating wire structures).
- Determine directions of maximum signal radiations and the nulls in the radiation patterns.
- Design array antenna systems from specifications.
- Identify the characteristics of radio-wave propagation.
- Identify wireless networks 4G and LTE, and 5G.
- Design cellular systems

SYLLABUS OF PHYSICS DSE 16

THEORY COMPONENT

Unit – I **(14 Hours)**

ANTENNA THEORY

Introduction: Antenna as an element of wireless communication system, antenna radiation mechanism, types of antennas, fundamentals of EMFT: Maxwell's equations and their applications to antennas

Antenna Parameters: Antenna parameters: Radiation pattern (polarization patterns, field and phase patterns), field regions around antenna, radiation parameters (general idea): intensity, beam width, gain, directivity, polarization, bandwidth, efficiency and antenna temperature

Unit – II **(5 Hours)**

Antenna as a transmitter/receiver: Effective height and aperture, power delivered to antenna, input impedance, general idea of radiation from an infinitesimal small current element and radiation from an elementary dipole (Hertzian dipole)

Unit – III **(5 Hours)**

WIRELESS NETWORKS:

Introduction: General idea of cellular and wireless systems, current wireless systems, examples of wireless communication systems, idea about global mobile communication system

Unit – IV **(3 Hours)**

Modern wireless communication systems: General idea 2G,3G and wi-fi, 4G and LTE, and 5G wireless networks, wireless local area networks (WLANs), bluetooth and personal area networks (PANs).

Unit – V **(3 Hours)**

Cellular Concept and System Design Fundamentals: Cellular concept and cellular system fundamentals, cellular systems design considerations (qualitative idea only)

References:

Essential Readings:

1) Antenna Theory, Ballanis, 2nd edition, 2003, John Wiley & Sons
2) Electro Magnetic Waves and Radiating Systems, Jordan and Balmain, E. C., 3rd edition, 1968, Reprint (2003), PHI
3) Fundamentals of Wireless Communication, D. Tse and P. Viswanathan, 2014, Cambridge University Press
4) Wireless communication and Networks, U. Dalal, 2015, Oxford University Press.
5) Mobile Communication Design and Fundamentals, Lee, William C.Y., 4th edition, 1999

Additional Readings:

1) Wireless communications, A. Goldsmith, 2015, Cambridge University Press
2) Modern Wireless Communication, H. S. and M. M. Pearson, 3rd edition, 2005

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Study of simple dipole and folded dipole (l/2) antenna, plot and compare the radiation pattern of both antennas.
2) Study of simple dipole 5 element Yagi-UDA and folded dipole 5 element Yagi Uda antenna, plot and compare the radiation pattern of both antennas
3) Study of loop antenna and slot antennas and plot their radiation patterns
4) Study the radiation pattern of ground plane antenna and observe the difference in radiation pattern with single element rod, detector and reflector rods
5) To study the variation of radiated field with distance from transmitting antenna.
6) To study modulation of sine wave on RF transmitted and observe the demodulated wave on detector receiver
7) Study of the reciprocity theorem for antennas
8) Study the role of matching stub in antenna transmission.
9) To study working of current sensor and measurement of current in various elements of antenna.
10) To study and measure SWR using various types of antennas.

11) To study different parts of a 4G Volte mobile phone and observe constellation diagram for transmitter and receiver IQ signals
12) To study various types of faults in a 4G volte mobile phone.

References for laboratory work:

1) Antenna Theory, Ballanis, 2nd edition, 2003, John Wiley & Sons
2) Fundamentals of Wireless Communication, D. Tse and P. Viswanathan, 2014, Cambridge University Press
3) Mobile Communication Design and Fundamentals, Lee, William C.Y., 4th edition, 1999