JADAVPUR UNIVERSITY

B. Sc. PHYSICS (HONS)

SYLLABUS

SCHEME FOR CHOICE BASED CREDIT SYSTEM

IN B.Sc. PHYSICS (HONS)

Semester	Core Course [14]	Ability Enhancement Compulsory Course [2]	Skill Enhancement Course [2]	Discipline Specific Elective [4]	Generic Elective [4]
I	CORE 1 (4+2) CORE 2 (4+2)	AECC 1(2) (English)			GE 1 (6)
II	CORE 3 (4+2) CORE 4 (4+2)	AECC 2(2) (Env. Sc.)			GE 2 (6) (Math)
III	CORE 5 (4+2) CORE 6 (4+2) CORE 7 (4+2)		SEC 1 (2) Comp. C++ /FORTRAN 90/ Python		GE 3 (6) (Math)
IV	CORE 8 (4+2) CORE 9 (4+2) CORE 10(4+2)		SEC 2 (2)		GE-4 (6)
V	CORE 11(4+2) CORE 12(4+2)			DSE 1 (6) DSE 2 (6)	
VI	CORE 13(4+2) CORE 14(4+2)			DSE 3 (6) DSE 4 (6)	
TOTAL CREDIT	84	04	04	24	24

Figures within [ ] and ( ) indicate number of courses and credit points, respectively.

B.Sc. Physics (Hons.) – Course details

A. <u>Core courses</u>

Sem	Course type	Course name	Course code	Teaching mode	Credit	Marks
I	CORE	Mathematical Physics-I	UG/SC/CORE/PHY/TH/01	Theory	4	50
			UG/SC/CORE/PHY/PR/01	Practical	2	50
	CORE	Mechanics	UG/SC/CORE/PHY/TH/02	Theory	4	50
			UG/SC/CORE/PHY/PR/02	Practical	2	50
II	CORE	Electricity and Magnetism	UG/SC/CORE/PHY/TH/03	Theory	4	50
			UG/SC/CORE/PHY/PR/03	Practical	2	50
	CORE	Waves and Optics	UG/SC/CORE/PHY/TH/04	Theory	4	50
			UG/SC/CORE/PHY/PR/04	Practical	2	50
III	CORE	Mathematical Physics-II	UG/SC/CORE/PHY/TH/05	Theory	4	50
			UG/SC/CORE/PHY/PR/05	Practical	2	50
	CORE	Thermal Physics	UG/SC/CORE/PHY/TH/06	Theory	4	50
			UG/SC/CORE/PHY/PR/06	Practical	2	50
	CORE	Digital systems and applications	UG/SC/CORE/PHY/TH/07	Theory	4	50
			UG/SC/CORE/PHY/PR/07	Practical	2	50
IV	CORE	Mathematical Physics-III	UG/SC/CORE/PHY/TH/08	Theory	4	50
			UG/SC/CORE/PHY/PR/08	Practical	2	50
	CORE	Elements of Modern physics	UG/SC/CORE/PHY/TH/09	Theory	4	50
			UG/SC/CORE/PHY/PR/09	Practical	2	50
	CORE	Analog systems and applications	UG/SC/CORE/PHY/TH/10	Theory	4	50
			UG/SC/CORE/PHY/PR/10	Practical	2	50
V	CORE	Quantum mechanics and applications	UG/SC/CORE/PHY/TH/11	Theory	4	50
			UG/SC/CORE/PHY/PR/11	Practical	2	50
	CORE	Solid state physics	UG/SC/CORE/PHY/TH/12	Theory	4	50
			UG/SC/CORE/PHY/PR/12	Practical	2	50
VI	CORE	Electromagnetic theory	UG/SC/CORE/PHY/TH/12	Theory	4	50
			UG/SC/CORE/PHY/PR/12	Practical	2	50
	CORE	Statistical Mechanics	UG/SC/CORE/PHY/TH/12	Theory	4	50
			UG/SC/CORE/PHY/PR/12	Practical	2	50

B. Discipline Specific Elective (DSE) courses

Semester	Course type	Course name	Course code	Teaching mode	Credit	Marks
V	DSE (any one)	Advanced Mathematical Physics	UG/SC/DSE/PHY/TH/01/A1	Theory	5	100
				Tutorial	1	
		Condensed matter physics	UG/SC/DSE/PHY/TH/01/A2	Theory	4	50
			UG/SC/DSE/PHY/PR/01/A2	Practical	2	50
	DSE (any one)	Nuclear and Particle Physics	UG/SC/DSE/PHY/TH/02/A1	Theory	5	100
				Tutorial	1	
		Atomic, molecular and LASER physics	UG/SC/DSE/PHY/TH/02/A2	Theory	4	50
			UG/SC/DSE/PHY/PR/02/A2	Practical	2	50
VI	DSE (any one)	Advanced Dynamics	UG/SC/DSE/PHY/TH/03/A1	Theory	4	50
			UG/SC/DSE/PHY/PR/03/A1	Practical	2	50
		Atmospheric Physics	UG/SC/DSE/PHY/TH/03/A2	Theory	4	50
			UG/SC/DSE/PHY/PR/03/A2	Practical	2	50
		Astrophysics	UG/SC/DSE/PHY/TH/03/A3	Theory	5	100
				Tutorial	1	
	DSE (any one)	Physics with computer simulation	UG/SC/DSE/PHY/TH/04/A1	Theory	4	50
			UG/SC/DSE/PHY/PR/04/A1	Practical	2	50
		Principles of Instrumentation andMeasurements	UG/SC/DSE/PHY/TH/04/A2	Theory	4	50
			UG/SC/DSE/PHY/PR/04/A2	Practical	2	50
		Biological physics	UG/SC/DSE/PHY/TH/04/A3	Theory	5	100
				Tutorial	1	

C. Ability Enhancement Compulsory courses

Semester	Course type	Course name	Course code	Teaching mode	Credit	Marks
I	AECC	English	Faculty offered course			
II	AECC	Environmental Science	Faculty offered course			

D. Skill Enhancement courses

Semester	Course type	Course name	Course code	Teaching mode	Credit	Marks
III	SEC1		Faculty offered course			
IV	SEC2 (Any one)	Basic Instrumentation skill	UG/SC/SEC/PHY/PR/02/A	Practical	2	50
		Physics workshop skill	UG/SC/SEC/PHY/PR/02/B	Practical	2	50

Program Outcomes (POs) of Science Faculty:

PO1: Foundational Scientific Knowledge: Apply the knowledge of mathematics and natural sciences to the solution of scientific problems.

PO2: Critical Thinking and Problem Analysis: Identify the problems and formulate various methodologies for obtaining their solutions.

PO3: Design/Development of Solutions: Design a system and prepare formal methodical plans, leading to solutions.

PO4: Conduct investigations of complex problems: Formulate the structure and components of a complex problem and investigate it for obtaining a solution

PO5: Usage of Modern Methods and Tools: Develop/ select and apply appropriate methods/tools for solving problems with an understanding of their limitations.

PO6: The Science and Society: Apply scientific knowledge to assess and address critical societal issues.

PO7: Environment and Sustainability: Appreciate social and environmental issues and provide scientific know-hows for the use of renewable resources.

PO8: Ethics: Understand professional, ethical, legal, societal and security issues, and responsibilities.

PO9: Individual and team work: Build capacity to work independently and also as a team member within an organization.

PO10: Communication: Develop skills to communicate effectively with superiors, colleagues, other team members as well as the society at large.

PO11: Project Management and Finance: Understand the management principles and appreciate financial implications/issues pertaining to any scientific project.

PO12: Life-long learning: Identify contemporary issues due to changing technical, political and social scenarios and engage in lifelong learning to update himself/herself.

Program Specific Outcomes (PSOs) of Physics Department:

PSO1: Interpret fundamental and advanced knowledge in Physics and their applications in solving scientific problems.

PSO2: Develop problem solving skills, thinking, creativity through assignments.

PSO3: Formulate and analyze various methods and techniques for designing the solution of the problems.

PSO4: Apply various concepts of Physics in solving real life problems associated with science, social science and technology.

A. Core Courses

SEMESTER - I

Mathematical Physics– I **Credits: 4**

Paper Code:UG/SC/CORE/PHY/TH/01

60 Lectures

The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

Recap: Limit, Continuity and differentiation, Plotting of functions and its inverses.

Calculus :

Functions of single variable : Differentiation, second [and higher] order differentiations and their geometric significance. Differentiation of a product of two functions, Leibniz Rule and its significance, Taylor Series, Binomial Series. [**2+4 Lectures**]

Functions of several variables: Calculus of Several Variables [new features], Implicit function theorem; Partial Differentiation, closed and exact differentiation, Maxima and Minima of 2 variables, geometry of functions of several variables, Tangent and Cotangent spaces, Homogenous Polynomials, varieties represented by polynomials, Eulers Theorem. [**8 Lectures**]

Ordinary Differential Equations : First and Second order ordinary differential equations, integrability and Quadrature, Integrating Factors and Exact differentials, 2nd order ODE with constant coefficients. **[8 Lectures]**

Infinite Series and Asymptotics : Summation and Convergence of Infinite Series, Convergence tests and Radius of Convergence , Asymptotic expansions and Borelresummation [**6 Lectures**]

Vectors and Tensors:

Vectors: Recap of vectors - Dot product, cross product and their geometric significance; Calculus of vectors - gradient , divergence, curl operations ; Integration of vectors over lines, curves, surfaces and volumes, Stokes Theorem, Gauss Theorem, geometric significance of flux, source and sink of a vector. Definition of vectors in terms of transformation properties under linear co-ordinate reparametrizations. [**8 Lectures**]

Curvilinear Coordinates:

Expressions for Grad, Div, Curl and Laplacian in general curvilinear coordinates and orthogonal system (e.g. Spherical, Polar, Cylindrical coordinate System).

[**2 Lectures**]

Cartesian Tensors : Basic Introduction and properties [strictly Cartesian cases only] general expression [in arbitrary, but otherwise flat/constant curvature co-ordinates] for divergence, gradient, curl and Laplacian. [**5 Lectures**]

Introduction to probability:

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing. **[5 Lectures]**

Fourier Series:

Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions Statement only]. Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite series. Term-by- Term differentiation and integration of Fourier Series. Parseval Identity.

[**8 Lectures**]

Theory of Matrices:

Basic introduction of matrices, Determinants, Eigen value problem and diagonalization.

[**4 Lectures**]

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning. Differential Equations, George F. Simmons, 2007, McGraw Hill.
3. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
4. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5th Ed, 2012, Jones and Bartlett Learning
5. Mathematical Physics, Goswami, 1st edition, Cengage Learning
6. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press Advanced
7. Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
8. Essential Mathematical Methods, K.F.Riley and M.P.Hobson, 2011, Cambridge Univ. Press.

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Solve the partial differential equations and ordinary differential equations encountered in physical problems.

CO2. Apply the knowledge of vectors and tensors to understand different physical phenomenon.

CO3. Learn the fundamentals and applications of Fourier series

CO4. Solve eigen value problems using matices.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	1	1	1								3	2	1	
CO2	3	1	1	1	1								3	2	1	
CO3	3	2	1	1	1								3	2	1	
CO4	3	1	1	1	1								3	2	1	

Mathematical Physics – I (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/01

(The course consists of both theory and practical in the laboratory)

1. **Introduction and overview**
   Classes of computers, desktop computer architecture and organization, memory and input/output devices
2. **Linux OS:** Familiarization of Linux Operating System (OS), logging in and logging out, graphical mode , text mode , absolute basics, the commands, directories, files, getting help.
   About files and the file system: The path, manipulating files, viewing file properties, creating and deleting files and directories, finding files, file permissions.
   Text editor: Using Vi editor, two modes, command mode and text mode, editing and printing documents, Emacs editor.
3. **Basics of scientific computing:** Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
4. **Errors and error Analysis:** Inherent, truncation and round off errors, absolute, relative and percentage errors, Floating- point arithmetic.
5. **FORTRAN 90 Programming fundamentals:** Introduction to FORTRAN 90 programming, numeric constants and variables, data types, operators and expressions, I/O statements, conditional statements, implementing loops, functions and subroutines, manipulating arrays (multi-dimensional), format specifications and file handling, use of modules.
6. **Introduction to plotting graphs with 'Gnuplot'** (or some other GUI based free software):
   (a) Basic 2D plot: plotting functions and data files, exporting plots.
   (b) Basic 3D plot: plotting contour and surface plots.
7. **Programs:**
   (a) Elementary calculations with different type of data, e.g., area and volume of regular shapes using formulae. Sum & average of a list of numbers stored in one dimensional array, finding the largest and smallest number from the given list of numbers, sorting of numbers in ascending and descending order, convergence and accuracy of series. Simple calculation of matrices: addition, subtraction, multiplication.
   (b) Evaluation and plotting of trigonometric functions such as $sin\theta$to study truncation error.
   (c) Curve fitting, Least square fit, Goodness of fit, standard deviation

(i) Ohms law to calculate R and

(ii) Hooke's law to calculate spring constant.

Note: C & C++ or python may be used instead of FORTRAN 90 as a programming language.

Reference Books:

1. Computer programming in FORTRAN 90 and 95 by V. Rajaraman
2. LINUX: Learning the essentials by K. L. James
3. Gnuplot cookbook by Lee Philips

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Learn basics of a computing system including Linux operating system, editing, printing etc.

CO2. Learn floating-point arithmetic in computations and errors in numerical experiments

CO3. Learn a high level language such as FORTRAN 90/ C / C++/ Python so that students will be able to write a computer program to numerically solve a physical program

CO4. Learn a graphics software, e.g., GNUPLOT, to visualize the output of a computer program.

CO5: Write computer programs for elementary problems which do not require any numerical analysis to perform.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	**3**	**2**	**2**	**2**	**2**								**3**	**3**	**2**	**1**
CO2	**3**	**1**	**2**	**2**	**1**								**3**	**3**	**2**	**1**
CO3	**3**	**2**	**2**	**2**	**1**								**3**	**3**	**2**	**1**
CO4	**3**	**1**	**2**	**2**	**1**								**3**	**3**	**2**	**1**
CO5	**3**	**2**	**2**	**2**	**2**								**3**	**3**	**2**	**1**

Mechanics **Credits: 4**

Paper Code: UG/SC/CORE/PHY/TH/02

60 Lectures

Newton's Laws of motion: Review of elementary problems. Motion of a particle in one dimension, time dependent force, velocity dependent damping force. Two dimensions motion of a particle [the harmonic oscillator, projectile motion], Components of velocity and acceleration in cylindrical and spherical coordinate systems. [**12 Lectures**]

Work and Energy: Work and Kinetic Energy Theorem. Conservative [position dependent] and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy. [**6 Lectures**]

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. [**6 Lectures**]

Elasticity: Hooke's law, Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion – Torsional pendulum-Determination of Rigidity modulus and moment of inertia, Beam supported at both ends. [**4 Lectures**]

Fluid Motion: Streamline and turbulent motion; Reynolds's number; Poiseuille's Equation for flow of a liquid through a capillary tube. [**2 Lectures**]

Gravitation: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. The simple pendulum, the compound pendulum, bar pendulum, correction for the finite amplitude. [**5 Lectures**]

Central Force Motion: Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system [GPS]. [**5 Lectures**]

Oscillations: SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. [**6 Lectures**]

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications.
[**4 Lectures**]

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity. Lorentz contraction. Time dilation. Relativistic transformation of velocity, Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. Energy- Momentum Four Vector.
[**10 Lectures**]

Reference Books:

1. Berkley Physics Course vol. I (Mechanics)
2. Halliday and Resnick; Physics, vol. I
3. Kleppner and Kolenkow; An Introduction to Mechanics
4. Goldstein: Classical Mechanics
5. Keith R. Symon: Mechanics
6. Thornton and Marion: Classical dynamics
7. Spiegel: Theoretical Mechanics

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Distinguish between inertia frame of reference and non-inertial frame of reference and build up the knowledge to apply the Newtons laws of mechanics on non-inertial frame.

CO2. State the conservation principles involving momentum, angular momentum and energy and understand that they emerge from the fundamental equations of motion.

CO3. Understand the dynamics of rotating objects i.e. rigid bodies, angular velocity, the moment of inertia, parallel axis theorem, the inertia tensor, the motion of rigid bodies.

CO4. Learn about motion of a particle under central force field and Kepler's laws are just consequences Newton's laws of gravitation.

CO5: Understand Lorentz transformations and apply them to develop the concepts of length contraction, time dilation, simultaneity of events and solve simple kinematical problems.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1									3	2	1	1
CO2	2	2	1	1									3	2	1	1
CO3	3	2	1	1									3	2	1	1
CO4	2	2	1	1									3	2	1	1
CO5	2	3	1	1									3	2	1	1

Mechanics (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/02

Preliminaries:

(i) Measurements of length (or diameter) using Vernier callipers, screw gauge and travelling microscope.

(ii) To study the random error in observations.

List of experiments:

1. Determination of moment of inertia (M.I.) of metallic cylinder about an axis perpendicular to its length and passing through its CG.
2. To determine the M.I. of a Flywheel.
3. To determine the modulus of rigidity of wire by dynamical method.
4. To determine Young's modulus of the material of a beam by the method of flexture.
5. To determine the elastic constants of a material by Searle's method.
6. To determine the coefficient of viscosity of water by capillary flow method (Poiseuille's method).
7. To determine the value of 'g' using bar pendulum.

8. To determine the value of ‘g’ by Kater’s pendulum.
9. To determine the height of a building using sextant.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
4. Advanced Practical Physics, Vol-I, B. Ghosh, 2^{nd} Edn, 2005, Sreedhar Publishers

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Determine moment of inertia of different systems

CO2. Determine elastic constants of solid by different methods.

CO3. Apply Poiseuille’s method to determine coefficient of viscosity.

CO4. Obtain value of acceleration due to gravity using various methods.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	2								3	3	2	1
CO2	3	1	2	1	2								3	3	2	1
CO3	3	2	2	1	2								3	3	2	1
CO4	3	1	2	1	2								3	3	2	1

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S E M E S T E R - II

Electricity and Magnetism **Credits: 4**

Paper Code: UG/SC/CORE/PHY/TH/03

Theory: 60 Lectures

Electric Field and Electric Potential

Gauss’ Law in Electrostatics and its applications to charge distributions [both uniform and non-uniform] with spherical, cylindrical and planar symmetry.

[6 Lectures]

Laplace’s and Poisson’s equations, Application of Laplace’s equation to simple symmetric cases, Uniqueness Theorem, the method of images and its application to [i] point charge near a conducting plane, [ii] pointcharge near a conducting sphere.

[6 Lectures]

Electrostatic energy of system of charges. Electrostatic energy density, Electrostatic energy of a charged sphere.

Conductors in an electrostatic Field. Surface charge and force on a conductor.

Capacitance of a system of charged conductors. Parallel plates, concentric spherical andcylindrical capacitors, energy stored in a capacitor. **10 Lectures]**

Dielectric Properties of Matter: Polar and non polar dielectrics, Potential and Electric Field of a dipole.

Force and Torque on a dipole. Mutual potential energy of two coplanar dipoles. Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant..Gauss' Law in dielectric media. Introduction of Displacement vector **D**. Relations between **E**, **P** and **D**. **[8 Lectures]**

Magnetic Field: Magnetic force on a moving charge , current element and definition of Magnetic Field **B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment [Analogy with Electric Dipole]. Ampere's Circuital Law and its application to [1] Solenoid and [2] Toroid.
Properties of **B**: Calculation of divergence and curl of B in a general case, boundary conditions, Magnetic vector potential- calculation of the vector potentials for straight current carrying conductors and solenoid.
Torque on a current loop in a uniform Magnetic Field. **[9 Lectures]**

Magnetic Properties of Matter: Magnetic field of magnetized objects and bound currents, Ampere's law in magnetized materials and the auxiliary field H. Magnetic properties of materials, susceptibility, magnetization vector[M], relationship between B, M and H, ferromagnetic materials,
B-H curve and hysteresis. **[4 Lectures]**

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Transients in LR, CR and LCR circuits,**[6 Lectures]**

Electrical Circuits: Alternating current, mean and r.m.s. values, AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Response of circuit elements [resistance, capacitance and inductance] toward sinusoidal waveform, impedance and admittances, sinusoids and phasor, phasor diagram, series and parallel RLC circuit, frequency response, resonance and quality factor; frequency.
[4 Lectures]

Network theorems: Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. **[4 Lectures]**

Ballistic Galvanometer: Construction and theory of Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping.CDR. **[3 Lectures]**

Reference Books:

1. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
2. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
3. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
4. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
5. Foundation of Electricity & Magnetism, B. Ghosh, 4^{th}Edn 2015 Books and Allied [P] Ltd.
6. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury2012, Tata McGraw

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Get basic knowledge of electrostatics and magnetostatics.
CO2.Understand the basic of dielectric and magnetic properties of matter.
CO3. Analyze and solve different a.c. circuits.
CO4. Apply different network theorems in the electrical circuit analysis.

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CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	1	1									3	2	1	1
CO2	3	1	1	1									3	1	1	1
CO3	3	2	1	1								1	3	2	1	1
CO4	3	1	1	1								1	3	1	1	1

Electricity and Magnetism (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/03

Preliminaries:

(i) Familiarization with electrical accessories including ballistic galvanometer.

(ii) Use of a Multimeter for measuring (a) resistances, (b) AC and DC voltages, (c) DC current, (d) capacitances, and (e) checking electrical fuses.

List of experiments:

1. To determine resistance of a galvanometer by a P.O. Box (Thomson's method).
2. To determine an unknown Low Resistance using Carey Foster's Bridge.
3. To determine an unknown Low Resistance using Potentiometer.
4. To study the characteristics of a series RC Circuit.
5. To verify the Thevenin and Norton theorems.
6. To verify the Superposition, and Maximum power transfer theorems.
7. To determine the horizontal component of Earth's magnetic field using magnetometer.
8. To verify Biot-Savart law.
9. To determine self- inductance of a coil by Anderson's bridge.
10. To determine the mutual inductance of two coils by Absolute method.
11. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
12. To determine a high resistance by leakage method using Ballistic Galvanometer.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practical , Michael Nelson and Jon M. Ogborn, 4th Edition,reprinted 1985, Heinemann Educational Publishers
3. Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
4. Advanced Practical Physics, Vol-I & II, B Ghosh, thEdn, 2005, Sreedhar Publishers

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Determine low resistance using bridge circuits and potentiometer.

CO2. Verify Thevenin and Norton and maximum power transfer theorems.

CO3. Use magnetometer to determine horizontal component of Earth's magnetic field .

CO4. Apply various methods to determine the values of self inductance and mutual inductance.

CO5: Design LCR circuit and study the resonance frequency, quality factor, band-width etc.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1	1								3	3	2	1
CO2	3	1	1	1	1								3	3	1	1
CO3	3	2	1	1	1								3	3	2	1
CO4	3	1	1	1	1								3	3	1	1
CO5	3	2	2	1	1								3	3	2	1

Waves and Optics — Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/04

60 Lectures

Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having [1] equal frequencies and[2] different frequencies [Beats]. Superposition of N collinear Harmonic Oscillation with [1] equal phase differences and [2] equal frequency differences.

[5 Lectures]

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.

[2 Lectures]

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive Waves. Differential Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.

[4 Lectures]

Velocity of Waves: Velocity of Transverse Vibrations in Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.

[5 Lectures]

Superposition of Two Harmonic Waves: Standing [Stationary] Waves in a String: Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. **[6 Lectures]**

Geometrical Optics:

Fermat's principle and its application to reflection and refraction at plane and spherical surfaces, Matrix method for paraxial rays: Ray transfer matrices (Translation and refraction matrices), Thick and thin lenses, Cardinal points, combination of lenses.

[4 Lectures]

Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

[3 Lectures]

Interference: Two classes of interference. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination[Haidinger Fringes]; Fringes of equal thickness [Fizeau Fringes]. Newton's Rings: Measurement of wavelength and refractive index.

[8 Lectures]

Interferometer: Michelson Interferometer-[1] Idea of form of fringes [No theory required], [2] Determination of Wavelength, [3] Wavelength Difference, [4] Refractive Index, and [5] Visibility of Fringes. Interference with multiple beams-Fabry-Perot interferometer.

[4 Lectures]

Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

[8 Lectures]

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Cornu's spiral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

[8 Lectures]

Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Applications of holograms. **[3 Lectures]**

Reference Books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.
5. A Text Book on Light, B Ghosh & K G Majumdar,5thEdn, 2003, Sreedhar Publishers
6. Principles of Acoustics, B Ghosh, 2ndEdn, 2007, Sreedhar Publishers
7. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Learn basic concept of simple harmonic vibrations and its applications to wave optics

CO2. Solve wave equations for both transverse and longitudinal waves and apply them in solving practical problems.

CO3. Understand the fundamental principle of geometrical and wave optics to explain various optical phenomena.

CO4. Introduce basics of quantum optics.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1									3	2	1	1
CO2	3	2	1	1									3	2	1	1
CO3	3	2	1	1									3	2	1	1
CO4	3	1	1	1									3	1	1	1

Waves and Optics (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/04

List of experiments:

1. To determine the frequency of an electric tuning fork by Melde’s experiment and verify λ^2 –T law.
2. To determine velocity of sound in liquid using ultrasonics.
3. Familiarization with Schuster`s focusing and determine refractive index of the Material of a prism using sodium source.
4. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
5. To determine wavelength of sodium light using Fresnel Biprism.
6. To determine wavelength of sodium light using Newton’s Rings.
7. To determine resolving power of a plane diffraction grating.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
4. Advanced Practical Physics, Vol-II, B Ghosh, 2nd Edn, 2005, Sreedhar Publishers

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Determine velocity of longitudinal wave in different medium.
CO2. Calibrate and focus optical instruments to measure optical properties of the materials.
CO3. Obtain wavelength of light using different techniques.
CO4. Estimate resolving powers of grating.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	1								3	2	2	1
CO2	3	1	2	1	1								3	1	2	1
CO3	3	2	2	1	1								3	2	2	1
CO4	3	1	2	1	1								3	1	2	1

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S E M E S T E R - III

Mathematical Physics– II Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/05

60 Lectures

The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

Fuchsian Differential Equations:

2nd Order ODE with 2 regular singular points, Frobenius Theorem on Integrability, Frobenius- Fuchs Method – (Power) Series Solutions, including the case of degenerate roots of the Indicial equation. The case of the generalised Hypergeometric equation discussed as the primary example, Congruent Hypergeometric function, Beta, and Gamma functions and Special Functions as special/limiting cases of the Generalized Hypergeometric functions, Analytic Continuation.

[**16 Lectures**]

Frobenius Method and Special Functions:

Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel and Henkel Functions Jo(x) and $J_1(x)$ and Orthogonality.

[**12 Lectures**]

Theory of Errors:

Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line.

[**8 Lectures**]

Partial Differential Equations:

The basic PDE's Physics [upto order 2]. Solutions to partial differential equations, using seperation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

[**14 Lectures**]

Method of Greens' Functions:

The basic PDE's of Physics [up to order 2] and their Green's functions [definition] and properties of Dirac Delta Function. Explicit calculations of the Greens function for the Laplacian, Wave-Operator, Heat/Schrodinger equation (Solutions in *dim* = 1,2 and 3 should be high-lighted).

[**10 Lectures**]

Reference Books:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differentials Equations, George F. Simmons, 2006, Tata McGraw-Hill
5. Partial Differential Equations for Scientists and Engineers, S.J.Farlow, 1993 , Dover Pub.
6. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
7. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Books Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Pub.

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Learn Frobenius method for series solutions of a wide class of second order ordinary differential equations to apply them in quantum mechanics of simple systems.

CO2. Solve and understand the behaviours of the wave-functions of Harmonic oscillator in their study of quantum mechanics on one hand, and also understand various potential problems that arise in the context of electrostatics on spherical geometries

CO3. Develop the skill for solving various non-homogeneous problems using Green's function involving external forcing on physical systems.

CO4. Study partial differential equations and understand problems with finite boundaries.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	2									3	2		
CO2	3	1	2	2									3	2		
CO3	3	2	2	2									3	2		
CO4	3	1	2	2									3	2		

Mathematical Physics - II (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/05

List of experiments:

1. Numerical solution of first order Ordinary Differential Equations (ODE) using Euler's method: Application to physical problems such as
   (a) Motion of a particle in resistive medium (drag force is considered as proportional to velocity of the

particle),
(b) Transient phenomena in electrical circuits: Growth and decay of current in LR circuit.

2. Root finding of non-linear algebraic or transcendental equations using Bisection and Newton-Raphson methods:
   Application to physical problems such as
   (a) Numerical solution of van der Waals' equation to study behavior of real gases.
   (b) To find the secondary maxima in case of Fraunhofer diffraction pattern due to a single slit.

3. Numerical differentiation and integration:
   Application to physical problems such as
   (a) Study of motion of an object in one dimension: finding velocity and acceleration from a set of observations of position of a particle at different time.
   (b) Calculation of Moment of Inertia (M.I) of a rigid body.

4. Numerical solution of a linear system of equations by Gauss elimination and Gauss Seidel methods:
   Application to physical problems such as
   (a) Solution of coupled mass-spring systems (3 masses).
   (b) Solving boundary value problem in electrostatics.

5. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems:
   Application to physical problems such as
   (a) Calculation of principal axes moment of inertia.
   (b) Solution of mesh equations of electrical circuits (3 meshes).

Note: Application to physical problems may not be exactly the same as suggested above.

Reference Books:

1. Computer programming in FORTRAN 90 and 95 by V. Rajaraman
2. Computational Methods for Physics by Debasish Lohar, Scientific International Pvt. Ltd., 2019
3. Computational Methods for Physics by Joel Franklin, Cambridge University Press, 2013.
4. Computational Physics: Problem solving with computers by Landau, Páez and Bordeianu
5. Computational Physics (2nd Edition) by Nicholas J. Giordano and Hisao Nakanishi

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Learn numerical analysis and write computer programs to solve first-order differential equations describing physical phenomena such as motion of a particle in resistive media, growth/decay of current in electrical circuits.

CO2. Use numerical analyses and write computer programs to solve numerically non-linear algebraic or transcendental equations describing different physical phenomena.

CO3. Write computer programs for numerical differentiation, integration, system of linear algebraic equations describing different physical phenomena.

CO4. Solve eigen value problems related to different physical phenomena using computer programming.

CO5: Understand handling physical problems which are analytically intractable.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	1								3	2	2	
CO2	3	2	2	1	1								3	2	2	
CO3	3	2	2	1	1								3	2	2	
CO4	3	2	2	1	1								3	2	2	
CO5	3	2	2	1	1								3	2	2	

Thermal Physics Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/06

60 Lectures

Introduction to Thermodynamics Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

[**8 Lectures**]

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. Auto and Rankine's cycles.

[**11 Lectures**]

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

[**7 Lectures**]

Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations.

[**7 Lectures**]

Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations, Maxwell's Relations:[1] Clausius Clapeyron equation, [2] Values of Cp-Cv, [3] TdSE quations, [4] Joule-Kelvin coefficient for Ideal and Van der Waal Gases, [5] Energy equations, [6]Change of Temperature during Adiabatic Process.

[**7 Lectures**]

Kinetic Theory of Gases Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy [No proof required]. Specific heats of Gases.

[**6 Lectures**]

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport

Phenomenon in Ideal Gases: [1] Viscosity, [2] Thermal Conductivity and [3] Diffusion. Brownian Motion and its Significance.

[**4 Lectures**]

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 Gas.Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Vander Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Vander Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.

[**10 Lectures**]

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger.1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2ndEd., 2012, Oxford University Press
7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Establish Ideal Gas Laws from the concept of Kinetic Theory of Gases.

CO2. Use statistical techniques to solve problems related to large sample size.

CO3. Analyze various transport processes when equilibrium of system is disturbed.

CO4. Learn about the behavior of real gases and techniques for liquefaction of real gases.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1									3	1	1	
CO2	3	1	1	1									3	1	1	
CO3	3	2	1	1									3	2	1	
CO4	3	1	1	1									3	1	1	

Thermal Physics (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/06

List of experiments:

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.

4. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).

5. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions.

6. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, AsiaPublishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
4. Advanced Practical Physics, Vol-I&II, B Ghosh, 2nd Edn, 2005, Sreedhar Publishers

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Determine the value of mechanical equivalent of heat.

CO2. Obtain the coefficient of thermal conductivity of conductors and bad conductors.

CO3. Calibrate Platinum resistance thermometer.

CO4. Calibrate a thermocouple and study the variation of Thermo-emf.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	1	1	1								3	2	1	
CO2	3	2	1	1	1								3	2	1	
CO3	3	2	1	1	1								3	2	1	
CO4	3	2	1	1	1								3	2	1	

Digital Systems and Applications — Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/07

60 Lectures

Introduction to CRO: Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: [1] Study of Waveform, [2] Measurement of Voltage, Frequency, and Phase Difference. **[3 Lectures]**

Integrated Circuits [Qualitative treatment only]: Active & Passive components, Discrete components, Wafer, Advantages and drawbacks of ICs, Scale of integration: SSI, MSI, LSI and VLSI [basic idea and definitions only], Classification of ICs, Examples of Linear and Digital ICs. **[3 Lectures]**

Number systems and codes: Binary ,Octal, Decimal and Hexadecimal number system ; Binary to decimal,

Decimal to binary, Hexadecimal to decimal and binary, binary to hexadecimal conversion , The ASCII code, Binary addition, subtraction, multiplication and division.

Logic gates: Basic idea about logic gates, AND, OR and NOT Gates [realization using Diodes and Transistor]. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

Boolean Algebra and Karnaugh map: Logic operators [AND, OR, NOT, NAND, NOR, XOR, XNOR], Boolean Algebra, De Morgan's theorem, Boolean identities, Minterm, Maxterm, truth table, SOP and POS form of Boolean expression, Karnaugh map [Pairs, Quads, Octets], Don't care condition, Simplification of Boolean expression using Boolean algebra and Karnaugh maps, , Implementation of digital logic circuit by NAND and NOR gate.

Combinational logic circuit: Difference between Analog and Digital Signals and Circuits, Definition, design procedure of combinational logic circuit, Comparators [1-bit, 2-bit, 4-bit, magnitude comparator], half adder, full adder, half subtractor, full subtractor, 4-bit binary Adder/Subtractor. code convertors: encoder, decoder. MUX, DEMUX .

Sequential logic circuit: Definition, difference between combinational and sequential logic circuit, latches and flip flop, S-R, D and J-K, Flip-Flop Level and edge triggered FF, Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. Conversion of flip-flop. **[27 Lectures]**

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers [only up to 4 bits]. **[3 Lectures]**

Counters [4 bits]: Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

[4 Lectures]

Computer Organization: Input/Output Devices. Data storage [idea of RAM and ROM]. Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map. **[6 Lectures]**

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. **[8 Lectures]**

Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions. **[6 Lectures]**

Reference Books:

1. Malvino: Electronic Circuits
2. Malvino and Brown: Digital computer Electronics

3. Anand Kumar: Fundamentals of Digital Electronics
4. Mano: Digital Designee

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Know the construction and use of cathode ray oscilloscope (CRO)

CO2. Learn the logic gates and their operations

CO3. Implement combinational and sequential logic circuits for different applications.

CO4. Know the internal organization, addressing modes and instruction sets of *8085* microprocessor.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	1								3	2	2	1
CO2	3	2	2	1	1								3	2	2	1
CO3	3	2	2	1	1								3	2	2	1
CO4	3	2	2	1	1								3	2	2	1

Digital systems and applications (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/07

List of experiments:

1. Applications of CRO to [i] Study of Waveform, [ii] Measurement of Voltage, Frequency, and Phase Difference.

2. To verify the truth table of AND, OR, NOT, NAND, NOR, EXOR gates using ICs.

3. To construct and study the truth table of OR, AND, NOT gates using diode.

4. To construct and study the truth table of OR, AND, NOT gates using transistors.

5. To construct and study the truth table of OR, AND, NOT gates using any type of universal gate NAND/NOR.

6. To design a combinational logic system for a specified Truth Table.

7. To convert a Boolean expression into logic circuit and design it using logic gate ICs.

8. To minimize a given logic circuit.

10. Half Adder, Full Adder and 4-bit binary Adder.

11. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.

11. To build Flip-Flop (SR, D latch, Clocked RS, D FF) circuits using NAND gates.

12. To design an astable multivibrator of given specifications using 555 Timer

Reference Books:

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1. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994,Mc-Graw Hill.
3. Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
4. Microprocessor 8085:Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.
5. Advanced Practical Physics, Vol-II, B Ghosh, 2^{nd} Edn, 2005, Sreedhar Publishers

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Construct and verify truth tables of logic gates using components and ICs.

CO2. Design and construct combinational logic circuits for specified Truth Tables and Boolean expressions.

CO3. Design and build combinational logic circuits for addition and subtraction of binary numbers.

CO4. Design and build circuits for binary data storage.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	1								3	2	2	1
CO2	3	3	2	1	1								3	3	2	1
CO3	3	3	2	1	1								3	3	2	1
CO4	3	2	2	1	1								3	2	2	1

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S E M E S T E R – IV

Mathematical Physics – III Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/08

Theory: 60 Lectures

The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

Complex Analysis:

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals. Functions of a single complex variable. Winding number, rectifiable curves, the LOG function, Holomorphic functions, entire and Meromorphic functions; Poles and Residues at infinity, [Contour] Integral Representation of some special functions in particular Beta and gamma functions [Hankel contour for the gamma functions].

[**26 Lectures**]

Integrals Transforms:

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train and other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms [translation, change of scale, complex conjugation, etc.]. Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations. One dimensional Wave and Diffusion/Heat Flow Equations.

[**10 Lectures]**

Laplace Transforms:

Laplace Transform [LT] of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform. Other useful transforms: Hilbert Schimdt Transform , Radon transform.

[**10 Lectures**]

Basics of linear algebra and linear operator:

Standard manipulation with matrices, determinants, eigen value problem and diagonalisation of matrices, notion of a trace of a matrix [Cayley Hamilton Theorem].Linear Operator and the eigenvalue problem : notion of Kernel, Co kernel and adjoint of an operator, normed linear spaces, hermitian and unitary operators , orthogonalisation [Gram Schmidt orthogonalisation] and degenerate cases to be discussed.

[**14 Lectures**]

Reference Books:

1. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications Complex
3. Variables, A.S.Fokas and M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press Complex
4. Variables , A.K. Kapoor, 2014, Cambridge Univ. Press
5. Complex Variables and Applications, J.W. Brown and R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
6. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones and Bartlett.

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Apply components of complex analysis to perform complex integrations of a wide variety of functions.

CO2. Solve differential equations using the technique of integral transforms.

CO3. Study Laplace transform of elementary functions and solve boundary value problems in electromagnetic theory and quantum mechanics

CO4. Use the concept of linear algebra to interpret formal structure of quantum mechanics as a whole and also certain topics of classical physics.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	1								3	2	2	
CO2	3	2	2	1	1								3	2	2	
CO3	3	2	2	1	1								3	2	2	
CO4	3	2	2	1	1								3	2	2	

Mathematical Physics - III (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/08

List of experiments:

1. Solution of second order ODE using Runge-Kutta second order and fourth order methods:
   Application to physical problems such as
   (a) Harmonic oscillator (without friction)
   (b) Damped harmonic oscillator
   (c) Realistic projectile motion

2. Solution of Partial Differential Equations (PDE) using finite difference approximation of fixed step size:
   Application to physical problems such as
   (a) Solution of one dimensional heat conduction equation using explicit scheme.
   (b) Solution of Laplace equation in two dimensions.

3. Generating and plotting of special functions (Legendre polynomials and Bessel function):
   Application to physical problems such as
   (a) Computation of electrostatic potential due to a point charge.
   (b) Computation of intensity distribution pattern for Fraunhofer diffraction due to a circular aperture.

4. Dirac-delta function:
   Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}}\int \frac{-(x-2)^2}{2\sigma^2}(x+3)dx$ for x = 1, 0.1, 0.001 and show that it tends to 5.

5. Fourier Series:

(a) Write a program to sum $\sum_{n=0}^{\infty}(0.2)^n$

(b) Evaluate the Fourier coefficient of a given periodic function (square wave).

6. Complex analysis:
   Find the two square roots of -5+12 i

7. Integral transform:
   FFT of e^{-x^2}

Reference Books:

1. Computational Physics by Badis Ydri, World Scientific Publishing Co., 2017.
2. Applied Computational Physics by Joseph F. Boudreau and Eric S. Swanson, Oxford University Press, 2018.
3. Computational Methods for Physics by Joel Franklin, Cambridge University Press, 2013.
4. Computational Methods for Physics by Debasish Lohar, Scientific International Pvt. Ltd., 2019

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Understand R-K method to solve IVP and write computer programs for solving second-order differential equations describing physical phenomena.

CO2: Utilize finite difference method and write computer programs to solve partial differential equations describing different physical phenomena.

CO3: Apply numerical analyses and write computer programs to generate and plot special functions.

CO4: Learn numerical analyses and write computer programs to perform Fourier analysis and Fourier transform.

CO5: Understand handling physical problems which are analytically intractable.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	1								3	2	2	
CO2	3	2	2	1	1								3	2	2	
CO3	3	2	2	1	1								3	2	2	
CO4	3	2	2	1	1								3	2	2	
CO5	3	2	2	1	1								3	2	2	

Elements of Modern Physics — Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/09

Theory: 60 Lectures

Blackbody Radiation: Planck's quantum, Planck's constant. Photo-electric effect and Compton scattering - light as a collection of photons. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.

[**12 Lectures**]

Position measurement; Wave-particle duality, Heisenberg uncertainty principle [Uncertainty relations involving Canonical pair of variables]: Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction.

[**5 Lectures**]

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

[**8 Lectures**]

One dimensional infinitely rigid box-energy eigenvalues and eigenfunctions, normalization; Quantum mechanical scattering and tunneling in one dimension-across a step potential & rectangular potential barrier.

[**8 Lectures**]

General Properties of Nuclei: Concept of atomic nucleus, constituents of nucleus, impossibility of an electron being in the nucleus as a consequence of uncertainty principle, nuclear size, mass and density, binding energy, average binding energy per nucleon and its variation with mass number, N - Z plot, angular momentum, parity, magnetic moment and electric moments.

[8 Lectures]

Radioactivity: Stability of the nucleus, law of radioactive decay, activity and its units, mean life and half life, radioactive series, successive disintegration, radioactive equilibrium.

Alpha - decay: basics of α - decay process, Geiger Nuttall law, theory of alpha – emission.

Beta - decay: energy and kinematics of beta decay, positron emission, electron capture, Pauli’s neutrino hypothesis, neutrino detection.

Gamma- decay: Gamma ray emission, gamma ray spectra and nuclear energy levels, passage of gamma ray through matter, internal conversion.

[10 Lectures]

Neutron Physics: Discovery of neutron, properties of neutron, sources of neutron, classification of neutrons according to energy, nuclear fission, general characteristics, simple explanation from liquid drop model, energy release, reactors, nuclear fusion and energy release in stars.

[5 Lectures]

Lasers: Einstein’s A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.

[**4 Lectures**]

Reference Books:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
4. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
5. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan
6. Nuclear Physics, Irving Kaplan, Narosa Publishing House

Additional Reference Books:

1. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
2. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
3. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
4. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
5. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill.
6. Nuclear Physics, S. N. Ghoshal, S. Chand and Co. Ltd.

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Involve transition from the classical domain of physics to the semiclassical and quantum domains.

CO2. Builds a bridge between the perception of the quantum world and real world through topics such as Bohr's Theory and the Uncertainty principle.

CO3. Describe the properties of nuclei and discuss the radioactive decay.

CO4. Learn the basic concepts of LASER.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	1								3	1	1	
CO2	3	1	1	1	1								3	1	1	
CO3	3	1	1	1	1								3	1	1	
CO4	3	1	1	1	1								3	1	1	1

Elements of Modern Physics (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/09

List of experiments:

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

9. To setup the Millikan oil drop apparatus and determine the charge of an electron.

10. To determine the wavelength of laser source using diffraction of single slit.

11. To show the tunneling effect in tunnel diode using I-V characteristics.

12. To determine the wavelength of laser source using diffraction of double slits.

13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011,Kitab Mahal.

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Verify the value of Planck's constant experimentally

CO2. Demonstrate the photoelectric effect.

CO3. Perform spectroscopic measurements and measure emission and absorption lines.

CO4. Determine wavelength of LASER source using diffraction phenomena.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	1	1	1								3	2	1	
CO2	3	2	1	1	1								3	2	1	1
CO3	3	2	1	1	1								3	2	1	1
CO4	3	2	1	1	1								3	2	1	1

Analog Systems and Applications Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/10

Theory: 60 Lectures

Semiconductor and Junction [Two-terminal Devices]: Intrinsic and extrinsic semiconductor [p-type, n-type], p-n junction diode, depletion region and barrier formation in p-n junction diode; band structure of semiconducting material and p-n junction at equilibrium, forward and reverse [bias basic idea]; Conductivity and Mobility, Concept of Drift velocity. I-V characteristics of semiconductor diode, Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode, avalanche and Zener breakdown, Zener diode, Principle and structure of Light Emitting diode [LED], photo diode, Schottky diode, Solar Cell.

[10 Lectures]

Application of diodes: Load line, half wave rectifier, full wave rectifier, Calculation of Ripple Factor and Rectification Efficiency, C-filter, clippers- clampers, voltage multiplier circuits, Zener regulated power supply.

[7 Lectures]

Transistor: Bipolar junction Transistor [BJT], n-p-n & p-n-p transistor construction, transistor characteristics in common emitter [CE], common base[CB], and common collector [CC] configuration, active, saturation and cut off regions, current gain α and β, relations between α and β, load line and operation point[Q-point], transistor biasing [fixed bias, emitter bias, voltage divider bias].

[8 Lectures]

Operational Amplifier: Differential amplifier circuit, differential gain, common mode gain and CMRR, characteristics of ideal op-amp, major building block of op-amp circuit [basic op-amp configuration], virtual ground concept, open loop and close loop configuration of op-amp, Application of op-amp: inverting and non-inverting configuration, unity gain buffer, summing amplifier, difference amplifier, constant current generator, integrator, differentiator, Log amplifier, Zero crossing detector, problems on op-amp circuits.

[15 Lectures]

Application of transistor and op-amp:

Power supply: Constant voltage and current source, series voltage regulator, Linear voltage regulator ICs.
Amplifier: performance parameter [gain, input and output impedance, band width, stability, distortion and noise], Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, voltage and power Gains. voltage and power amplifier: class A, class B, class C, cross-over distortion, push-pull amplifier, effect of feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise, Coupled amplifier: direct coupled, RC-coupled amplifier, inductively coupled; Feedback principle, Oscillator: basic principle of oscillation [Barkhausen's Criterion for self-sustained oscillations], type of oscillator, tuned controlled, Hartley, Colpitts, phase shift, Wien-bridge and crystal oscillator.
Timers: IC 555: Block diagram and applications: Astablemultivibrator and Monostablemultivibrator.

D/A and A/D convertors: A/D signal conversion: quantization, Sampling, D/A convertors [weighted resistor, R-2R ladder], S/H circuit, A/D convertors [successive approximation resistor type and parallel flash].

[20 Lectures]

Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
6. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn.,Oxford University Press.
7. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
8. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
9. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Explain the basic characteristics of p-n junction diode and their applications.
CO2. Understand the working principle of a junction transistor and its behavior in a circuit.
CO3. Learn the basic concepts of operational amplifier and its various applications
CO4. Design, construct and analyze power supply, amplifiers and A/D and D/A converters.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	3	1	1	1	1								3	1	1	1
CO2	3	1	1	1	1								3	1	1	1
CO3	3	2	1	1	1								3	2	1	1
CO4	3	2	1	1	1								3	2	1	1

Analog systems and applications (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/10

List of experiments:

1. To study V-I characteristics of PN junction diode, and Light emitting diode.

1. To study the V-I characteristics of a Zener diode and its use as voltage regulator.

2. To study the ripple factor of half wave and full wave rectifiers with and without filter.

3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.

4. To study the various biasing configurations of BJT for normal class A operation.

5. To study the characteristic of FET.

6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.

7. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain.

8. To design inverting amplifier using Op-amp (741,351) and study its frequency response.

9. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response.

10. To study the zero-crossing detector and comparator.

11. To design a circuit to simulate the solution of a 1^{st}/ 2^{nd}order differential equation.

12. To design a Wien bridge oscillator for given frequency using an op-amp

13. To design a digital to analog converter (DAC) of given specifications.

14. To study the analog to digital convertor (ADC) IC.

Reference Books:

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A.Miller, 1994, Mc-Graw Hill.
2. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.

3. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
4. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson.

Course Outcomes:
On completion of this course, the students will be able to:
CO1. Study the characteristics of junction diode, zener diode and light emitting diodes.
CO2. Study various biasing configurations of BJT and FET
CO3. Design circuits using Op-amp for different applications
CO4. Design and study A/D and D/A converters.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	1	1	1											
CO2	3	1	1	1	1											
CO3	3	2	1	1	1											
CO4	3	1	1	1	1											

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S E M E S T E R - V

Quantum Mechanics and Applications Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/11

Theory: 60 Lectures

Schrodinger Equation
Description of a particle using wave packets, Spread of the Gaussian wave-packet for a free particle in one dimension, Fourier transforms and momentum space wave function.

Bound State solutions of the Schrodinger equation
Continuity of wave function, boundary condition and emergence of discrete energy levels, Some exact solution of the one dimensional Schrodinger equation.

i) Particle in a one dimensional infinitely deep potential well.

ii) Particle in a one dimensional potential well of finite depth.

One dimensional barrier transmission problems

Quantum mechanical scattering and tunneling across (i) a step potential (ii) rectangular potential barrier.

Linear harmonic oscillator

Setting up the eigenvalue equation for the Hamiltonian. Energy levels and energy eigenfunctions in terms of

Hermite polynomials (Solution to Hermite differential equation may be assumed). Ground state, zero point energy & uncertainty principle. Introduction of raising and lowering operators and solution of the Hamiltonian of in terms of them.

Hydrogen-like atoms

Reduction of a two body problem to a one body problem. The time independent Schrodinger equation for a particle moving under a central force - the Schrodinger equation in spherical polar coordinates. Separation of variables. Angular equation and orbital angular momentum. Spherical Harmonics (Solution to Legendre differential equation may be assumed). Radial equation for attractive coulomb interaction - Hydrogen atom. Solution for the radial wave functions (Solution to Laguerre differential equation may be assumed). Shapes of the probability densities for ground & first excited states. Orbital angular momentum quantum numbers l and m; s, p, d shells.

Generalized Angular Momenta and Spin.

(a) Generalized angular momentum. Electron's magnetic Moment and Spin Angular Momentum. Gyromagnetic Ratio and Bohr Magneton and the g - factor. Energy associated with a magnetic dipole placed in magnetic field. Larmor's Theorem. Stern-Gerlach Experiment.

(b) Addition of angular momenta - statement only. Restriction of eigenvalues from $|j_1 - j_2|$ to $|j_1 + j_2|$.

Spectra of Hydrogen atom and its fine structure

(a) Formula for first order non-degenerate and degenerate perturbative correction to the eigenvalue - statement only.

(b) Spin-orbit interaction and relativistic correction to the kinetic energy and Darwin term.

(c) Fine structure of the hydrogen atom spectrum

Atoms in Electric & Magnetic Fields

(a) Zeeman Effect: Normal and Anomalous Zeeman effect (Formula for first order perturbative correction to the eigenvalue to be assumed).

(b) Paschen Back effect & Stark effects (Qualitative Discussion only).

Many electron atoms

(a) Identical particles. Symmetric & Antisymmetric Wave Functions. Pauli's Exclusion Principle. Hund's

Rule. Periodic table.

(b) Fine structure splitting. L-S and J-J coupling scheme. Spectral Notations for Atomic States and Term symbols. Spectra of Alkali Atoms (Na etc.).

Books:

1. Gasiorowicz: Quantum Mechanics
2. Crawford: Quantum Mechanics
3. Merzbacher: Quantum Mechanics

Course Outcomes:

On completion of this course, the students will be able to:
CO1. Interpret wave functions and solve the Schroedinger equation for simple 1D time-independent potentials.
CO2. Solve non-relativistic hydrogen atom, for its spectrum and eigenfunctions.
CO3. Study the influence of electric and magnetic fields on atoms
CO4. Understand quantum many body problems.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	1	1	1								3	2	1	
CO2	3	2	2	1	1								3	2	2	
CO3	3	2	2	1	1								3	2	2	
CO4	3	2	2	1	1								3	2	2	

Quantum mechanics and applications (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/11

List of experiments:

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = (r)(r), \qquad A(r) = \frac{2m}{{}^2}[(r) - E], \qquad where\ (r) = -\frac{e^2}{r}$$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e=3.795 $(eVÅ)^{1/2}$, c=1973 (eVÅ) and m=0.511x10^6eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = (r)(r), \qquad A(r) = \frac{2m}{{}^2}[(r) - E]$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

$$V(r) = -\frac{e^2}{r} e^{\frac{-r}{a}}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wave function. Take e =3.795 $(eVÅ)^{1/2}$,m=0.511x10^6eV/c^2, and a = 3Å, 5 Å, 7Å. In these units c=1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{d^2y}{dr^2} = (r)(r), \qquad A(r) = \frac{2m}{{}^2}[(r) - E]$$

for the anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k=100 MeV fm^{-2}, b=0, 10, 30 MeV fm^{-3}. In these units, c=197.3 MeV fm. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dr^2} = (r)(r), \qquad A(r) = \frac{2\mu}{{}^2}[(r) - E]$$

Where μ is the reduced mass of the two-atom system for the Morse potential

$$(r) = (e^{-2\alpha r^{F}} - e^{-2\alpha r^{F}}), r' = \frac{r - r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take m = 940 MeV/c^2,
D=0.755501 eV, α =1.44, r_o= 0.131349Å.

Reference Books:

1. Computational Physics by Badis Ydri, World Scientific Publishing Co., 2017.
2. Applied Computational Physics by Joseph F. Boudreau and Eric S. Swanson, Oxford University Press, 2018.
3. Computational Methods for Physics by Joel Franklin, Cambridge University Press, 2013.

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Learn numerical analysis to solve a boundary value problem (BVP) using shooting method.

CO2: Students will be able to solve Schrodinger equation using shooting method.

CO3: Learn numerical analysis to solve Schrodinger equation using direct matrix (finite difference) method.

CO4: Students will be able to apply direct matrix method to find energy eigen values and their corresponding eigen functions for hydrogen atom, screened coulomb potential, anharmonic oscillator and Morse potential.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	**3**	**2**	**1**	**1**	**1**								**3**	**2**	**1**	
CO2	**3**	**1**	**1**	**1**	**1**								**3**	**1**	**1**	
CO3	**3**	**2**	**1**	**1**	**1**								**3**	**2**	**1**	
CO4	**3**	**1**	**1**	**1**	**1**								**3**	**1**	**1**	

Solid State Physics — Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/12

Theory: 60 Lectures

Crystal Structure:

Solids: Amorphous and Crystalline Materials. Bravais and non-Bravais Lattices. Examples of Lattices. Primitive Vectors. Unit Cell. Primitive Cell. Atomic Packing Fraction. Reciprocal Lattice. Miller Indices. Inter-planar Spacing. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factors.

[**12 Lectures**]

Elementary Lattice Dynamics:

Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustic and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of Specific Heat of Solids. T^3 law.

[**10 Lectures**]

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of Dia- and Paramagnetic Materials. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis loop and Energy Loss.

[**8 Lectures**]

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.

[**8 Lectures**]

Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

[**6 lectures**]

Elementary Band Theory: Kronig Penney model. Band Gap. Conductor, Semiconductor [P and N type] and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity [04 probe method] & Hall coefficient.

[**10 Lectures**]

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equations and Penetration Depth. Isotope effect. Idea of BCS theory [No derivation]

[**6 Lectures**]

Reference Books:

1. Introduction to Solid State Physics, by Charles Kittel, Wiley
2. Solid State Physics, N.W. Ashcroft and N.D. Mermin, Cengage Learning
3. Fundamentals of the Physics of Solids: Vol. 1, 2 and 3: A. Piróth and Jenö Sólyom, Springer India
4. Introduction to Solids, Leonid V. Azaroff, Tata Mc-Graw Hill
5. Solid-state Physics, H. Ibach and H. Luth, Springer
6. Solid State Physics, Rita John, McGraw Hill
7. Condensed Matter Physics, by Michael P. Marder, Wiley

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Learn basics of crystal structure and know how the structure is determined from x-ray diffraction.

CO2. Understand the relation between the structure and various properties of solid.

CO3. Know the theory of lattice vibration to gain insights into the thermal properties of solid.

CO4. Lean electronic properties, such as , magnetic, dielectric properties of solid.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	1	1	1											
CO2	3	2	1	1	1											
CO3	3	2	1	1	1											
CO4	3	2	1	1	1											

Solid State Physics (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/12

List of experiments:

1. To measure the Magnetic susceptibility of Solids.
2. To determine the Coupling Coefficient of a Piezo-electric crystal.
3. To measure the Dielectric Constant of a dielectric Materials with frequency
4. To determine the refractive index of a dielectric layer using SPR
5. To study the PE Hysteresis loop of a Ferroelectric Crystal.
6. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150^{o}C) and to determine its band gap.
7. To determine the Hall coefficient of a semiconductor sample.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice Hall of India.

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Measure the Magnetic susceptibility of solids

CO2. Measure the Dielectric Constant of materials

CO3. Study hysteresis loop of Ferroelectric crystals

CO4. Apply four-probe method to determine resistivity and band-gap of semiconductors.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	1	1	1								3	2	1	
CO2	3	2	1	1	1								3	2	1	
CO3	3	2	1	1	1								3	2	1	
CO4	3	2	1	1	1								3	2	1	

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S E M E S T E R - VI

Electromagnetic Theory — Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/13
Theory: 60 Lectures

Maxwell Equations: The generalization of Ampere's law, displacement current, Maxwell's equations and their empirical basis, the wave equation in vacuum, the Poynting vector and the Poynting theorem. Electromagnetic [EM] Energy Density. Physical Concept of Electromagnetic Field Energy Density,

EM Wave Propagation in Unbounded Media: Plane EM waves through vacuum and isotropic dielectricmedium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

[**10 Lectures**]

EM Wave in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular &parallel polarization cases, Brewster's law. Reflection& Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection [normal Incidence]

[**10 Lectures**]

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism.

Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light

[**12 Lectures**]

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

[**5 Lectures**]

Wave Guides: Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves.

Field energy and Power transmission.

Optical Fibres:-Classification, Acceptance angle and Numerical Aperture. Step and Graded Indices .Intermodal dispersion in step index fibre and Applications. [**3 Lectures**]

Reference Books:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
3. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
5. Reitz and Milford: Electromagnetic Theory

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Explore Maxwell’s equations and their applications.

CO2. Explore the propagation of electromagnetic in vacuum, conducting and dielectric medium

CO3. Imbibe the idea of rotary polarization, verification of Fresnel’s theory

CO4. Understand the physics of waveguides, optical fibers and their applications.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	1								3	2	1	
CO2	3	1	1	1	1								3	2	1	1
CO3	3	1	1	1	1								3	2	1	
CO4	3	1	1	1	1								3	2	1	1

Electromagnetic Theory (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/13

List of experiments:

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet’s compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.

8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.

9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.

10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.

11. To verify the Stefan`s law of radiation and to determine Stefan's constant.

12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Reference Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
4. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer.

Course Outcomes:
On completion of this course, the students will be able to:
CO1. Experimental verification of different phenomena of polarization of light
CO2. Demonstrate reflection, refraction, polarization and interference of microwaves.
CO3. Determination of refractive index of liquids and solids.
CO4. Verify Stefan's law.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1	2								3	2	2	
CO2	3	1	1	1	2								3	2	2	
CO3	3	1	1	1	2								3	2	2	
CO4	3	1	1	1	2								3	2	2	

Statistical Mechanics Credits: 4

Paper Code: UG/SC/CORE/PHY/TH/14

Theory: 60 Lectures

Classical Statistics:
[a] Concept of probability distribution – Discrete and continuous, Central limit theorem, random walk problem. Relevant probability distributions. [**5 Lectures**]

[b] Macrostate & Microstate, Elementary Concept of Ensemble and Ergodic hypothesis, Postulates of equilibrium statistical mechanics. Micro canonical ensembles, Statistical definition of various thermodynamic quantities. Entropy and Thermodynamic Probability. [**5 Lectures**]

[c] Concept of Phase Space, Liouvilles theorem, Boltzamann H- theorem. Canonical ensemble, Partition Function, Calculation of partition function of Harmonic Oscillators, ideal gas. Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy [with proof] – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. [**8 Lectures**]

[d] Grand Canonical ensemble and chemical potential, Grand partition function, entropy. [**2 Lectures**]

Classical Theory of Radiation: Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. [**8 Lectures**]

Quantum Theory of Radiation: Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of [1] Wien's Distribution Law, [2] Rayleigh-Jeans Law, [3] Stefan-Boltzmann Law, [4] Wien's Displacement law from Planck's law. [**6 Lectures**]

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, 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. [**13 Lectures**]

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, magnetism, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. [**13 Lectures**]

Reference Books:

1. Reif**:** Statistical Physics
2. Reif: Statistical and Thermal Physics
3. Mandl: Statistical Physics

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Learn the basic concepts of microstates, macrostates, thermodynamic probability and phase space.

CO2. Explain the fundamentals of thermodynamics using classical theory of radiation.

CO3. Describe black-body radiation in the light of quantum theory.

CO4. Explain the statistical behavior of ideal Bose and Fermi systems.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	1	1	1								3	2	1	
CO2	3	2	1	1	1								3	2	1	
CO3	3	2	1	1	1								3	2	1	
CO4	3	2	1	1	1								3	2	1	

Statistical Mechanics (Practical) Credits: 2

Paper Code: UG/SC/CORE/PHY/PR/14

List of experiments:

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   (a) Study of local number density in the equilibrium state (i) average; (ii)fluctuations
   (b) Study of transient behavior of the system (approach to equilibrium)
   (c) Relationship of large N and the arrow of time
   (d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
   (e) Computation and study of mean molecular speed and its dependence on particle mass
   (f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed.

2. Computation of the partition function $Z(\beta)$ for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
   (a) Study of how $Z(\beta)$, average energy $\langle E \rangle$, energy fluctuation ΔE, specific heat at constant volume C_v, depend upon the temperature, total number of particles N and the spectrum of single particle states.
   (b) Ratios of occupation numbers of various states for the systems considered above
   (c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.
3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.
4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.
5. Plot the following functions with energy at different temperatures:

(a) Maxwell-Boltzmann distribution

(b) Fermi-Dirac distribution

(c) Bose-Einstein distribution.

Reference Books:

1. Computational Physics by Badis Ydri, World Scientific Publishing Co., 2017.
2. Applied Computational Physics by Joseph F. Boudreau and Eric S. Swanson, Oxford University Press, 2018.
3. Computational Methods for Physics by Joel Franklin, Cambridge University Press, 2013.

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Learn Verlet algorithm in solving 2nd order ODE in connection with molecular dynamics simulations and hence calculate the average thermo-dynamical variables.

CO2: Numerically compute partition functions along with averaged values of thermodynamic quantities under MB, FD and BE statistics.

CO3: Generate pseudo random numbers and use them for random walk problems.

CO4: Numerically formulate Maxwell speed distribution function at different temperature and finding of mean speed, root mean speed and most probable speed.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	1								3	2	2	
CO2	3	2	2	1	1								3	2	2	
CO3	3	2	2	1	1								3	2	2	
CO4	3	2	2	1	1								3	2	2	

B. Discipline Specific Elective Papers (DSE)

S E M E S T E R - V

DSE-1

Advanced Mathematical Physics **Credits: 6**

Paper Code: UG/SC/DSE/PHY/TH/01/A1

(Credits: Theory - 5, Tutorial - 1)
Theory: 75 Lectures

The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

Calculus of Variations:

Calculus of Variations, Basic idea of maxima and minima of functions. Idea of a functional. Typical problem of calculus of variation. Isoperimetric problem. The Rayleigh -Ritz method. The second variation and the Legendre condition. Variational Principle, Euler's-Lagrange's Equation and its Applications. Geodesics.

Concept of Lagrangian, Generalized co-ordinates, Definition of canonical momentum, Euler-Lagrange's Equations of Motion and its Applications. Canonical Pair of Variables. Definition of Generalized Force: Definition of Hamiltonian (Legendre Transformation). Hamilton's Principle. Poisson Brackets and their properties. Lagrange Brackets and their properties.

[30 Lectures]

Differential forms:

Simple idea of a manifold. Definition of one, two and n- forms. The tangent and co-tangent space. Dual forms- vector fields. Basic algebra of forms. Wedge product. Exterior differentiation. Generalized Leibnitz rule. Equations of physics in the language of forms- Maxwell's equations. Maxwell's relations in thermodynamics. **[15 Lectures]**

Group Theory:

Review of sets, Mapping and Binary Operations, Relation, Types of Relations. Groups: Elementary properties of groups, uniqueness of solution. Subgroups and cosets, Center of a Group, Cyclic group. Conjugate elements, class and factor groups. Isomorphism and homo- morphism. Illustration with point symmetry groups Reducible and imeducible representations. Schur's lemma. Normal and conjugate subgroups, Completeness and Kernel. the orthogonality theorem. Continuous groups: The rotation group. The parameter space. Composition law. Transformation or Lie groups. Contact transformation as an example. Infinitesimal transformation. Idea of an algebra. The concepts of roots and weights. The special unitary groups SU(2) and SU(3), their algebras. Some special groups with operators. Matrix Representations: Reducible and Irreducible.

[30 Lectures]

Reference Books:

1. Mathematical Methods for Physicists: Weber and Arfken, 2005, Academic Press.
2. Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.
3. Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley
4. Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover Publications.
5. Introduction to Mathematical Physics: Methods and Concepts: Chun Wa Wong, 2012, Oxford University Press.
6. Abstract Algebra: David Steven Dummit and Richard M. Foote, John Wiley publications.
7. Abstract Algebra: Israel Nathan Herstein, John Wiley Publications.1986.
8. The Geometry of Physics: Theodore Frankel, Cambridge University Press.2011.
9. Differential Forms with Applications to the Physical Sciences: Harley Flanders, Dover Publications, 1989.
10. Representation Theory: A First Course: Joe Harris and William Fulton, Graduate Texts in Mathematics, Springer .1991.

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Learn variational calculus and apply in various Physical problems specifically the analytical problems of classical mechanics.

CO2: Understand basics of Legendre transformations that find immense applications in Thermodynamics.

CO3: Learn language of Differential Forms describing Maxwell's electrodynamics and other gauge theories.

CO4: Learn the basics of group theory and use it in studying symmetry aspects.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	1								3	2	2	
CO2	3	2	2	1	1								3	2	2	
CO3	3	2	2	1	1								3	2	2	
CO4	3	2	2	1	1								3	2	2	

Condensed Matter Physics **Credits: 4**

Paper Code: UG/SC/DSE/PHY/TH/01/A2

Theory: 60 Lectures

STRUCTURES AND SYMMETRIES OF CRYSTALS: Translational Symmetry in Crystals, Bravais Lattices, Primitive Cell, Wigner–Seitz Cells, Reciprocal Lattices, Brillouin Zone, Rotations and Reflection Symmetries, Crystallographic Point Groups, Symmetries of Two and Three Dimensional Bravais Lattices. Classification of Bravais Lattices, Types of Crystal Structures, X-ray Diffraction by Crystal, Von Laue Formulation in Reciprocal Space, Equivalence of Bragg's Law and Von Laue Formulation.

(10 Lectures)

DYNAMICS OF ELECTRON WITHIN CRYSTAL: Born–von Karman Boundary Condition, Bloch's Theorem, Schrödinger Equation in Reciprocal Space, Equivalent Wave Vectors, Crystal Momentum, Symmetry Properties of Energy Eigenstates, Kronig-Penney Model in Reciprocal Space, Electrons in a Weak Periodic Potential, Tight-Binding Method, Wannier Functions, Band Structures, Equation of Motion of Electron Under External Force Field, Concept of Holes, Effective Mass, Symmetry Breaking and Goldstone's Theorem. **(15 Lectures)**

FREE ELECTRON SYSTEMS: Sommerfeld model, Fermi-Dirac Distribution, Fermi Sphere, Fermi Energy, Density of States, Sommerfeld Expansion, Fermi Level at Non-zero Temperatures, Electronic Specific Heat, Pauli Paramagnetism, Electronic Transport, Boltzmann Transport Equation for Electrons, DC,AC and Optical Conductivity, Transport Coefficients, Thermal Conductivity, Wiedemann-Franz Law, Hall effect, Hall Coefficient, Quantum Hall Effect, Degeneracy of Landau Levels, Landau Diamagnetism.

(15 Lectures)

MAGNETIC SYSTEMS: Bohr-Van Leeuwen Theorem, Larmor Diamagnetism, Van Vleck Paramagnetism, Magnetic Orders, Ferromagnet, Antiferromagnet, Ferrimagnet, Coulomb and Exchange Integrals for Diatomic Molecules, Heisenberg Exchange Hamiltonians, Classical Ground States for Ferromagnet and Antiferromagnet, Direct Exchange, Indirect Exchange, Superexchange, Double Exchange, Mean-field Results of Ferromagnetic Heisenberg Systems, Curie-Weiss law, Ferromagnetic Spin-wave Excitation, Magnon Dispersion Relation, Bloch-$T^{3/2}$ Law, Magnetic Specific Heat.

(12 Lectures)

NANOSCALE SYSTEMS: Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

(8 Lectures)

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Explain crystal structure using the concept of symmetry and X-ray diffraction of the crystals using the knowledge of reciprocal lattice.

CO2: Associate the concept of free electron Fermi gas with classical free electron theory and explain various transport and magnetic properties of solids.

CO3: Explain various types of magnetic phenomenon, physics behind them, their properties and applications.

CO4: Gain basic knowledge in physics of nanomaterials and explain their unique properties.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1									3	2	1	
CO2	3	2	1	1									3	2	1	
CO3	3	2	1	1									3	2	1	1
CO4	3	1	1	1									3	1	1	1

Condensed Matter Physics (Practical) **Credits: 2**

Paper Code: UG/SC/DSE/PHY/PR/01/A2

List of experiments:

1. Measurement of band gap of a semiconductor by measuring its resistivity with temperature.
2. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method).
3. To draw the BH curve of Fe using Solenoid and determine energy loss from Hysteresis.
4. Measurement of Hall coefficient of a semiconducting sample.
5. Band gap variation with dimension for nanocrystalline materials.

Books:

1. Introduction to Solid State Physics, C. Kittel, John Wiley and Sons
2. Quantum Theory of Solids, C. Kittel, John Wiley and Sons
3. Solid State Physics, N.W. Ashcroft and N.D. Mermin, Cengage Learning
4. Fundamentals of the Physics of Solids: Volume 1, 2 and 3: by A. Piróth and J. Sólyom, Springer
5. The Physics of Solids, E. N. Economu, Springer
6. Solid-state Physics, H. Ibach and H. Luth, Springer
7. Quantum Theory of the Solid State: An Introduction, L. Kantorovich, Springer
8. Condensed Matter Physics, by M. P. Marder, Wiley
9. Principles of the Theory of Solids, J. M. Ziman, Cambridge University Press
10. Introduction to Nanotechnology, C.P. Poole, Jr. Frank J. Owens, Wiley India Pvt. Ltd.
11. Introduction to Nanoscience and Technology, K.K. Chattopadhyay and A. N. Banerjee, PHI Learning Private Limited.

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Measure band gap of a semiconductor.
CO2: Measure susceptibility of paramagnetic solution.
CO3: Demonstrate Hall effect and obtain the Hall co-efficient.
CO4: Determine the effect of size on optical properties of nanomaterials.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	2								3	2	2	
CO2	3	1	1	1	2								3	2	2	
CO3	3	1	1	1	2								3	2	2	
CO4	3	1	1	1	2								3	2	2	

DSE-2

Nuclear and particle physics

Credits: 6

Paper Code: UG/SC/DSE/PHY/TH/02/A1

(Credits: Theory - 5, Tutorial - 1)
Theory: 75 Lectures

Recapitulation: general properties of nuclei, elementary ideas about nuclear models, nuclear force and radioactivity.

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q value, reaction rate, reaction cross section, Concept of compound and direct Reactions, resonance reactions, S. N. Ghoshal's experiment for verification of compound nuclear hypothesis. Coulomb scattering (Rutherford scattering).

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation, Gamma ray interaction with matter, photoelectric effect, Compton scattering, pair production, neutron's interaction with matter.

Detector for Nuclear Radiations: Gas detectors: ionization in gaseous medium and gas amplification. Ionisation chamber and GM counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

Particle Accelerators: Van-de Graa generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons and betatron.

Cosmic rays: Nature, origin and properties of cosmic rays, experimental studies.

Particle Physics: Fundamental particles and their families. Fundamental particle-interactions and their basic features. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm. Quark model, color quantum number and gluons. Quark structure of hadrons.

Reference Books:

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Nuclear Physics, Irving Kaplan, Narosa Publishing House
- Nuclear Physics, S. N. Ghoshal, S. Chand and Co. Ltd.
- Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press.
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons.
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
- Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991) 97

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Recapitulate the basics of nuclear physics

CO2: Learn about the nuclear reaction and estimation of reaction cross section

CO3: Grow detailed understanding about the interaction of nuclear radiation with matter and techniques for their detection

CO4: Develop the concept of production of energetic particles by building different types of accelerators as well as learn about the natural sources of energetic particles

CO5: To grow the basic understanding of the elementary particles and their interactions.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1									3	1	1	
CO2	3	1	1	1									3	1	1	
CO3	3	1	1	1									3	1	1	
CO4	3	1	1	1	1								3	1	1	
CO5	3	1	1	1									3	1	1	

Atomic, Molecular and LASER Physics **Credits: 4**

Paper Code: UG/SC/DSE/PHY/TH/02/A2

Theory: 60 Lectures

Atomic Physics: Atomic spectra, Sommerfield's elliptic orbits, relativistic corrections (qualitative), space quantization, magnetic moments of atoms, Larmor's Theorem, Stern-Gerlach experiment, Pauli's Exclusion Principle, Vector atom model and the coupling between orbital and spin angular moment, alkali spectra, Zeeman effect, Selection rules for transitions, Term symbols. Spectra of hydrogen atom, Paschen Back & Stark effects (Qualitative Discussion).

Molecular Physics: Microwave spectroscopy: rotational spectra of diatomic molecules, Vibration spectra, FTIR Spectroscopy, Born-Oppenheimer (BO) approximation and separation of electronic and nuclear motion in molecule, Electronic spectroscopy, Frank Condon principle, Raman effect, LCAO (Qualitative discussion), Absorption spectroscopy and Beer-Lambert law, Applications of DFT calculations in the determination of molecular structures and vibrations (Qualitative discussion).

Laser Physics: Laser characteristics, Stimulated and Spontaneous emissions, Einstein's A and B coefficients, Line shape function $g(\omega)$, Population inversion & Threshold condition for lasing, Examples of lasers: solid state laser (Ruby Laser), Gas laser (He-Ne and CO_2 laser), Application of lasers in optics (Qualitative discussion).

Reference Books:

1. Introduction to Atomic Spectra – H E White
2. Atomic and Nuclear Physics – S N Ghosal
3. Fundamentals of Molecular Spectroscopy – C N Banwell
4. Introduction to Molecular Spectroscopy – G M Barrow
5. Introduction to Atomic and Nuclear Physics – H Semat and J R Albright
6. LASERS-Fundamentals and Applications – A. Ghatak and K. Thyagarajan.

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Understand the origin of atomic spectra

CO2. Elucidate in details the structure of an atom in the light of classical, semi-classical and quantum theory

CO3. Explore rotational, vibrational and electronic spectra of molecules.

CO4. Basic principles of LASERs and applications.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	1								3	1	1	
CO2	3	1	1	1	1								3	1	1	
CO3	3	1	1	1	1								3	1	1	
CO4	3	1	1	1	1								3	1	1	1

Atomic, Molecular and LASER Physics (Practical) **Credits: 2**

Paper Code: UG/SC/DSE/PHY/PR/02/A2

1. To determine the number of lines per unit length of a given plane diffraction grating using known wavelengths and hence to determine the wavelength separation between the D lines of sodium by using a slit of adjustable width and the resolving power of the grating.
2. Verification of Beer-Lambert's law and estimation of unknown concentration of a given solution from the measurement of optical density using colorimeter.
3. To determine the angle of divergence of laser beam emitting from semiconductor and He-Ne Laser.
4. To determine the particle size of lycopodium powder using semiconductor laser.
5. Study of Zeeman effect

Course Outcomes:
On completion of this course, the students will be able to:
CO1. Determine the number of lines per unit length of a given plane diffraction grating.
CO2. Verify tge Beer-Lambert's law
CO3. Estimate the angle of divergence of LASER beam.
CO4. Study of Zeeman effect

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	1								3	2	1	
CO2	3	1	1	1	1								3	2	1	
CO3	3	1	1	1	1								3	2	1	
CO4	3	1	1	1	1								3	2	1	

S E M E S T E R - VI

DSE-3

Advanced Dynamics **Credits: 4**

Paper Code: UG/SC/DSE/PHY/TH/03/A1

Theory: 60 Lectures

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as a dynamical system (system of first order ordinary differential equations).Examples - free particle, particle under uniform gravity, simple and damped harmonic oscillator, non-linear oscillators. Sketching flows and trajectories in phase space; sketching coordinates and momenta as functions of time. Relating equations and phase diagrams etc. to understand the nature of underlying physical processes.

Coupled mechanical systems as system of first order dynamical systems: coupled harmonic and anharmonic oscillators. Understanding phase space in multi-variable cases. Sketching variables as functions of time. Fixed points, stability of fixed points, linear stability analysis, basin of attraction, analysis of dynamical systems, with applications to the above examples and systems outside physics.

Biology: Population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics.

Chemistry: Rate equations for chemical kinetics.

Study of Bifurcation: Saddle-Node, Pitchfork (supercritical and subcritical), Transcritical, Hopf. Computing and visualizing trajectories on the computer using software packages. Discrete dynamical systems. The logistic map as an example.

[30 Lectures]

Introduction to Chaos and Fractals: Examples of 2-dimensional billiard, Projection of the trajectory on momentum space. Sinai Billiard and its variants. Computational visualization of trajectories in the Sinai Billiard. Randomisation and ergodicity in the divergence of nearby phase space trajectories, and dependence of time scale of divergence on the size of obstacle. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems; visualisation of their trajectories on the computer.

Self similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Fractals in dynamics – Serpinski gasket and DLA. Chaos in nonlinear finite-difference equations- Logistic map: Dynamics from time series. Parameter dependence- steady, periodic and chaos states. Cobweb iteration. Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions.

Period- Doubling route to chaos.

Nonlinear time series analysis and chaos characterisation: Detecting chaos from return map. Power spectrum, autocorrelation, Lyapunov exponent, correlation dimension.

[20 Lectures]

Elementary Fluid Dynamics: Basic physics of fluid: the continuum hypothesis – concept of fluid element or fluid parcel, fluid properties: viscosity, surface tension, compressibility and other properties, flow phenomena: flow dimensionality, steady and unsteady flows, laminar and turbulent flows, rotational and irrotational flows, compressible and uncompressible flows, flow visualization: streamlines, pathlines and streaklines.

Methods describing fluid motion: Lagrangian description and Eulerian description, equations of viscous fluid motion: continuity equation, Navier-Stokes equation and their application to simple flows.

[10 Lectures]

Reference Books:

1. Nonlinear Dynamics And Chaos: With Applications To Physics, Biology, Chemistry, And Engineering - Steven H. Strogatz.
2. Nonlinear Ordinary Differential Equations: An Introduction for Scientists - Dominic Jordan and Peter Smith.
3. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
4. Elementary fluid dynamics – D. J. Acheson, Oxford University Press, 1990.
5. An introduction to fluid dynamics – G. K. Batchelor, Cambridge University Press, 2000.

Course Outcomes:

On completion of this course, the students will be able to:

CO1. Understand physics of simple dynamical systems.

CO2. Analyse dynamical systems, with applications to coupled mechanical systems and systems outside physics.

CO3. Solve the trajectories of chaotic systems and use fractal geometry to model rough data and natural shapes.

CO4. Study the basic physics of fluid dynamics.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	3	1	1	1	1								3	1	1	
CO2	3	2	1	1	1								3	2	2	
CO3	3	2	2	1	1								3	2	2	
CO4	3	1	1	1	1								3	2	2	

Advanced Dynamics (Practical) — Credits: 2

Paper Code: UG/SC/DSE/PHY/PR/03/A1

1. To study the characteristic features of a nonlinear harmonic oscillator: Solve numerically the

corresponding equation and draw the phase portrait diagram to explain the characteristic features.

2. Repeat the experiment no. 1 with an inclusion of a damping term.
3. To study population models, e.g., exponential growth and decay, species competition, predator-prey dynamics.
4. To study rate equations for chemical reactions. e.g., auto catalysis, bistability.
5. To study period doubling leading to chaos using a simple logistic map.
6. Computational visualization of fractal formations of fractals in nature – trees, coastlines.
7. Computational flow visualization – streamlines, pathlines, streaklines.

Course Outcomes:
On completion of this course, the students will be able to:
CO1. Solve numerically and draw the phase portrait diagram to explain the characteristic features of nonlinear harmonic oscillator with and without damping.
CO2. Study rate equations for chemical reactions.
CO3. Computationally visualize fractal formations in nature.
CO4. Computationally visualize fluid flows.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	1								3	2	2	1
CO2	3	1	2	1	1								3	2	2	1
CO3	3	2	2	1	1								3	2	2	1
CO4	3	1	2	1	1								3	2	2	1

Atmospheric Physics

Credits: 4

Paper Code: UG/SC/DSE/PHY/TH/03/A2

Theory: 60 Lectures

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations, including RS/RW, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms.

(12 Lectures)

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi- annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics. **(12 Lectures)**

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration. **(12 Lectures)**

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.

(12 Lectures)

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars. **(12 Lectures)**

Reference Books:

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

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Have a basic understanding about the general features of the Earth’s atmosphere followed by different synoptic and mesoscale atmospheric phenomena over Indian region.

CO2: Learn atmospheric dynamics of large-scale and mesoscale circulations with emphasis on tropical dynamics.

CO3: Understand atmospheric waves in different spatial and temporal scales.

CO4: Learn the importance and impact of atmospheric aerosols in radiative forcing and health hazards.

CO5: Gain idea about in-situ and remote sensing measurements of atmospheric variables.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	1		1						3	1	1	1
CO2	3	1	1	1	2		2						3	1	1	1
CO3	3	1	1	1	2		2						3	1	1	1
CO4	3	1	1	1	2		2						3	1	1	1
CO5	3	1	1	1	2		2						3	1	1	1

Atmospheric Physics (Practical) **Credits: 2**

Paper Code: UG/SC/DSE/PHY/TH/03/A2

Simulations experiments based on Atmospheric Physics problems like

1. Numerical Simulation for atmospheric waves using dispersion relations
   (a) Atmospheric gravity waves (AGW)
   (b) Kelvin waves
   (c) Rossby waves, and mountain waves
2. Offline and online processing of radar data
   (a) VHF radar,
   (b) X-band radar, and
   (c) UHF radar
3. Offline and online processing of LIDAR data
4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.
5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique
6. Time series analysis of temperature using long term data over metropolitan cities in India–an approach to understand the climatechange

Reference Books:

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

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Learn simulating atmospheric waves in different spatial and temporal scales.

CO2: Familiar with RS/RW data and interpret, calculate different parameters related to convective processes.

CO3: Understand offline/online processing of RADAR/LIDAR data.

CO4: Handle satellite data to plot different atmospheric variables.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	1		1						3	1	1	1
CO2	3	1	1	1	2		2						3	1	1	1
CO3	3	1	1	1	2		2						3	1	1	2
CO4	3	1	1	1	2		2						3	1	1	2

Astrophysics **Credits: 6**

Paper Code: UG/SC/DSE/PHY/TH/02/A1

(Credits: Theory - 5, Tutorial - 1)
Theory: 75 Lectures

Basic Astronomy and astrophysics: Mass, length and timescales, Celestial coordinates, Magnitudes, Astronomy at different wavelengths. [**8 Lectures]**

Radiative Transfer Processes: Equations of radiative transfer, absorption and emission, atomic processes, Optical depth, Opacity, Local thermodynamic equilibrium, Spectral line formation, continuum and line emission. **[12 Lectures]**

Stellar Structure -Evolution, and Nucleosynthesis: Hydrostatic equilibrium, Virial theorem, Energy transport, Convective Instability, HR Diagram, Stellar evolution, Formation of Sun like Star, Eddington luminosity limit. Sources of stellar energy: gravitational collapse, fusion reactions, p-p chain, CNO cycle, triple α reactions, formation of heavy elements. Big bang nucleosynthesis.

[20 Lectures]

Binary Star Systems and Accretion Processes: Different types of binary stars; Importance of binary systems; Roche-lobe overflows, Accretion; Observational basis, proto-stars, disks, bipolar outflows, Basic fluid and plasma equations, Spherical accretion, Bondi flow. Stellar Collapse and

[10 Lectures]

Formation of Compact Objects: Degeneracy pressure, Chandrasekhar mass limit, White Dwarfs, Neutron Stars and Pulsars, and black holes, Schwarzschild metric, Singularities and the concept of a horizon. Gravitational radiation. **[10 Lectures]**

Galaxies: Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo), The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms, Active Galaxies

[5 Lectures]

Large scale structure & expanding universe: Cosmic Distance Ladder (An Example from Terrestrial

Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter), Friedmann Equation and its Solutions, Cosmic Background Radiation,

[10 Lectures]

Reference Books:

1. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4 th Edition, Saunders College Publishing.
2. The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
3. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
4. Astrophysics for Physicists by A. Rai Choudhuri
5. Introduction to Stellar Evolution and Nucleo-synthesis by D. Clayton.
6. Radiative Processes in Astophysics , George B.~Rybicki, Alan P.~Lightman, Wiley-VCH , 1986.

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Understand the hierarchical architecture of the cosmos, increasing in scale from the Solar System to the Galaxy to the Universe, and decreasing in scale to atoms and their nuclei.

CO2: Learn the equation of radiative transfer which describes the propagation of radiation through a medium is affected by absorption, emission, and scattering processes in astrophysical context.

CO3: Learn hydrostatic equilibrium concept and have use it to solve problems in astrophysics, and interpret the results.

CO4: Describe the structure and evolution of stars and formation of Compact stellar Objects..

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1		1	1								3	1	1	
CO2	3	2	1	1	1								3	1	1	
CO3	3	2	2	1	1								3	1	1	
CO4	3	2	2	2	1								3	1	1	

DSE-4

Physics with Computer Simulation **Credits: 4**

Paper Code: UG/SC/DSE/PHY/TH/04/A1

Theory: 60 Lectures

Classical Physics

The chaotic pendulum: analytic solution, numerical solution, Poincare section, basins of attraction, period-doubling bifurcations and chaos. Dynamics of three-body problem: Euler's solution. Fermi-Pasta-Ulam model. Duffing equation. Motion in more than one dimension.

Quantum Physics:

Numerical solutions of Schrödinger equations. Numerov's algorithm, Boundary conditions and finding of eigen functions and energies. Estimation of ground state energy by variational Monte Carlo technique.

Statistical Physics

Random and self-avoiding walks. Molecular dynamics: (i) Maxwell velocity distribution, (ii) Brownian motion. Study of phase transition in Ising and Potts models: internal energy, magnetization, Binder cumulant, specific heat and magnetic susceptibility. Monte Carlo simulations by (i) Metropolis and (ii) cluster algorithms. Thermal equilibrium of hard sphere gas.

Solid State Physics

Solution of periodic potential by transfer matrix method. Bloch's theorem. Kronig-Penney model, dispersion relations and density of states. Lattice vibrations: monoatomic and diatomic bases, dispersion relation and density of states.

Reference Books:

1. Computational Physics by J. Thijssen, Cambridge University Press.
2. Computational Physics by Morten Hjorth-Jensen.
3. Computational Physics: Simulation of Classical and Quantum Systems by Philipp O. J. Scherer, Springer.
4. Computational Physics by Nicholas J. Giordano, Prentice Hall.
5. Monte Carlo Methods in Statistical Physics by M. E. J. Newman and G. T. Barkema, Clarendon Press
6. Introduction to Practice of Molecular Simulation by A. Satoh, Elsvier.
7. Computational Physics by R. H. Landau, M. J. Paez and C. C. Bordeianu, Wiley.
8. Computational Physics by R. Fitzpatric, The University of Texas at Austin.
9. Computational Physics by Mark Newman

Course Outcomes:

On completion of this course, the students will be able to:

CO1: construct phase space portrait for simple pendulum, along with damped and driven pendulams ultimately leading to chaos in this way.

CO2: Understand the dynamics of three body systems, like sun-earth-moon, earth-moon-spacecraft systems by solving their equation of motion numerically.

CO3: Study thermodynamic properies of correlated systems by using Metropolis and cluster algorithmes

CO4: Learn how to solve periodic potential numerically using transfer matrix method.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	1								3	1	1	
CO2	3	1	1	1	1								3	1	1	
CO3	3	1	1	1	1								3	1	1	
CO4	3	1	1	1	1								3	1	1	

Physics with Computer Simulation (Practical) **Credits: 2**

Paper Code: UG/SC/DSE/PHY/PR/04/A1

1. Prediction of the orbit of a satellite by solving its equation of motion under gravitational pull, viscous drug and thrust due to its own internal fuel combustion.

2. Numerical solution of the driven damped pendulum.

3. Numerical solutions of the Fermi-Pasta-Ulam model.

4. Numerical solutions of the Duffing equation.

5. Numerical solutions of the three-body problems.

6. Numerical solutions of the *N*-body problems: simulations of galaxies.

7. Estimation of root-mean-square (rms) displacement of a random walker and a self-avoiding walker on lattices of various dimensions.

8. Simulation of molecular collision (elastic) leading to the Maxwell velocity distribution.

9. Computation of equation of state for hard sphere gas.

10. Numerical solutions of one-dimensional potential well.

11. Variational estimation of ground state energy for (i) harmonic oscillator, (ii) hydrogen and (iii) helium atoms.

12. Determination of critical temperature of continuous phase transition of spin-1/2 Ising model by using Monte Carlo simulations with (i) Metropolis and (ii) cluster algorithms.

13. Numerical estimation of critical temperature for thermodynamic phase transition of two-dimensional classical ***xy*** model (Kosterlitz-Thouless transition) by using Monte Carlo simulations with Metropolis algorithm.

14. Computation of dispersion relation by solving the Schrödinger equation of the one-dimensional periodic potential.

15. Computation of dispersion relation and density of states of an electron in a one-dimensional periodic potential by using transfer matrix.

16. Computation of phonon dispersion relation and density of states of a simple cubic lattice.

Course Outcomes:
On completion of this course, the students will be able to:

CO1: Predict orbit of a satellite by solving its equation of motion under different forces.
CO2: Numerically solve various physical problems.
CO3: Numerically estimate critical temperature for thermodynamic phase transition using Monte Carlo simulations.
CO4: Obtain dispersion relation and density of states by computation

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1	1								3	1	1	
CO2	3	2	2	1	1								3	1	1	
CO3	3	2	2	1	1								3	1	1	
CO4	3	2	1	1	1								3	1	1	

Principles of Instrumentation and Measurements **Credits: 4**

Paper Code: UG/SC/DSE/PHY/TH/04/A2

Theory: 60 Lectures

Instruments accuracy, precision, sensitivity, resolution range etc. errors in measurements: systematic and random errors, propagation of errors, Normal Law of errors, standard and probable error.

Low Temperature Physics and Vacuum Techniques: Production of low temperature, thermodynamics of liquefaction, Joule-Thompson liquefier, cryogenic system design, cryostat design, heat transfer, temperature control, Adiabatic demagnetization.

Cryogenic thermometry: gas and vapour pressure thermometers, resistance, semiconductor and diode capacitance thermometers, thermocouples, magnetic thermometry.

Vacuum pumps: Pumping speed, conductance and molecular flow; rotary pump, diffusion pump, turbo molecular pump; vacuum gauges ; Macleod, Pirani and ionization gauges.

Electrical measurements: A. C. meters, dynamometer type moving coil ammeter and voltmeter, moving iron and hot wire instruments, induction type instruments, wattmeters and energy meters.

Ballistic galvanometer: Torque on a current carrying conductor, ballistic galvanometer and its current and charge sensitivity, electromagnetic damping, logarithmic damping, critical damping resistance; use of ballistic galvanometer for measurements of (i) magnetic flux, (ii) self inductance, (iii) mutual inductance , (iv) high resistance by leakage.

Absolute determination of the ohm and the ampere, standard of resistance, voltage, inductance and capacitance, absolute and secondary measurements; generalized Wheatstone bridges for the measurement of R, L and C, common AC bridges.

Three phase systems, star and delta connections, rotating magnetic field, three phase and single phase induction motors.

Reference Books:

1. Sayer and Mansingh: Measurement, Instrumentation and Experiment Design in Physics and Engineering,

2. Ghosh: Introduction to Measurements and Instrumentation,

3. Rangan, Sarma and Mani: Instrumentation Devices and Systems,

4. Patranabis: Principles of Electronic Instrumentation

Course Outcomes:

On completion of this course, the students will be able to:

CO1: Understand the concept of accuracy, precision, sensitivity of instruments.
CO2: Learn the basic principles of low temperature physics and vacuum technology
CO3: Explain working principles of different electrical instruments
CO4: Make three phase and single phase electrical connections.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	1								3	1	1	
CO2	3	1	1	1	1								3	1	1	
CO3	3	1	1	1	1								3	1	1	1
CO4	3	1	1	1	1								3	1	1	1

Principles of Instrumentation and Measurements (Practical) **Credits: 2**

Paper Code: UG/SC/DSE/PHY/PR/04/A2

List of experiments:

1. Determination of capacity of a condenser by Anderson’s method.
2. Determination of self Inductance by Anderson Bridge.
3. Determination of self Inductance by Owen’s method.
4. To calibrate a thermocouple with the help of potentiometer and hence (i) to measure the thermoelectric power at a particular temperature, (ii) to measure an unknown temperature.

5. Measurement of Strain using Strain Gauge.

6. Measurement of level using capacitive transducer.

7. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)

8. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).

9. Create vacuum in a small chamber using a mechanical (rotary) pump and

measure the chamber pressure using a pressure gauge.

10. To design and study the Sample and Hold Circuit.

11. Design and analyze the Clippers and Clampers circuits using junction diode

12. To measure Q of a coil and influence of frequency, using a Q-meter.

Course Outcomes:
On completion of this course, the students will be able to:
CO1: Apply bridge circuits to determine capacitance and self-inductance values.
CO2: Calibrate a thermocouple with the help of potentiometer.
CO3: Calibrate and demonstrate temperature sensors.
CO4: Design and analyze the Sample & Hold Circuit and Clippers & Clampers circuits.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	1								3	1	1	1
CO2	3	1	1	1	1								3	1	1	1
CO3	3	1	1	1	1								3	1	1	1
CO4	3	1	1	1	1								3	1	1	1

Biological Physics

Credits: 6

Paper Code: UG/SC/DSE/PHY/TH/04/A3

(Credits: Theory - 5, Tutorial - 1)
Theory: 75 Lectures

Overview: Origin of life on Earth, From Molecules to the first cell, From Prokaryotes to Eukaryotes, From Single cell to multicellular organisms. Primitive Earth Conditions – anoxic reductive atmosphere, relatively high temperature, Volcanic eruption, radioactivity, high frequency UV radiation. The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems.Time scales and spatial scales.

Molecules of life:

Carbohydrates : Structural aspects – Introduction & Occurrence, Classification of Mono-, Di- and Polysaccharides, Reducing & Non-reducing Sugars, Constitution of Glucose & Fructose,

Lipids: Structural aspects – General introduction, Classification & Structure of Simple & Compound lipids, Properties of Lipid aggregates (elementary idea),

Proteins : Structural aspects – General introduction, amino acid, Classification & General characteristics, Structure of Primary, Secondary, Tertiary & Quaternary proteins (elementary idea), Their sizes, types and roles in structures and processes, transport, energy storage, membrane formation etc.

Nucleic acids: DNA and RNA, Structures, Functions. Experimental evidences for establishing DNA as hereditary material. Formation of proteins from DNA. (BDC)

Water and Bonds: Polar molecules, Hydrogen bond, Electrostatic interaction, Vander Waals Interaction, Hydrophobic Interactions,

Membrane architecture, compositions, lipid vesicles and planar Bilayer as a model system of biological membrane, preparation of unilamellar vesicles and characterization, membrane permeability, membrane fluidity, lipid bilayer and early models, fluids mosaic model.

Models of membrane fusion: basic physical principle of bilayer fusion, ion transport in biological membrane. importance of ions in cells, electrostatics in model membrane.

Physical properties of membrane: elastic properties, elastic constants, such as bending and stretching moduli, measurement of elastic constants: micropipette aspiration and fluctuation spectroscopy.

Phase transition of membrane, simple theory and qualitative description, effect of cholesterol on the properties of the membranes, cholesterol induced lateral phase separation, charge-induced microstructures and domain, raft hypothesis, protein induced phase transition and its implications.

Biophysical techniques: optical microscopy, fluorescence spectroscopy, single molecule biophysics, elementary concept of optical tweezer, magnetic tweezer, thermodynamics of biomolecular interaction, isothermal titration calorimetry.

Radiation Physics: Radiation Unit's exposure, absorbed dose, units: rad, gray, relative biological effectiveness, effective dose- Rem & Sievert, inverse square law. Interaction of radiation with matters. Compton & photoelectric effect, linear attenuation coefficient. Radiation Detectors: ionization (Thimble chamber, condenser chamber), chamber. Geiger Muller counter, Scintillation counters and Solid State detectors, TFT. (BDC)

Biophysical processes: Diffusion, Osmosis, Centrifugation. Principles and Mathematical Laws. Determination of molecular weight of protein using these techniques. (BDC)

Books:

Kim Sneppen& Giovanni Zocchi;Physics in molecular biology

Philip Nelson: Biological physics:energy,information,life

Rob Philips et al: Physical biology of the cell

UriAlon: An introduction to Systems biology

M.Ridley: Evolution

Course Outcomes:

On completion of the course, the students will be able to

CO1: Understand how the structures of different biological molecules are related with its function to maintain normalcy of the living system.

CO2: Learn architechture, composition and physical properties of membranes.

CO3: Understand techniques to analyze biological systems.

CO4: Explain interaction of radiation with matters and describe different radiation detectors.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	1	1	1	1								3	1	1	1
CO2	3	1	1	1	1								3	1	1	1
CO3	3	1	1	1	1								3	1	1	1
CO4	3	1	1	1	1								3	1	1	1

D. Skill Enhancement Course (SEC)

SEC-1

(to be offered by Faculty of Science)

SEC-2

Basic Instrumentation Skills Credits: 2

Paper code: UG/SC/SEC/PHY /PR/02/A

Mechanical Skill Development:

A Concept of workshop practice. Overview of manufacturing methods : casting, foundry, machining. forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron-metal sheets. composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, sharper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block . Use of bench vice and tools for fitting. Make funnel using metal sheet.

Electrical and Electronics Skill Development:

Basic Electrical principles: Voltage, current, resistance, power, Ohm's law; series, parallel and series/parallel combinations. AC electricity and DC Electricity: familiarization with, voltmeter ammeter, wattmeter and multimeter.

Printed Circuit Board (PCB) design.

Understanding Electrical Circuits: Single-phase and three-phase alternating current sources, rules to analyze DC/AC sourced electrical circuits, current and voltage drop across the circuit elements, operation of transformers.

Electrical Wiring: Different types of conductors and cables, basics of wiring, star and delta connection, voltage drop and losses across cables and conductors. Insulation, solid and stranded cable. Conduit, Cable trays, Splices: wire nuts, crimp, terminal blocks, split bolts and solder.

Digital Instruments: Principle and working of digital meters, comparison of analog & digital instruments, characteristics of a digital meter, working principles of digital voltmeter.

Multimeter: Block diagram and working of a digital multimeter, specifications of a multimeter

Cathode Ray Oscilloscope: Block diagram of CRO. Construction of CRT, Electron gun, electrostatic focussing and acceleration (Explanation only-no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization, front panel controls, probes, specifications of a CRO and their significance.

Use of CRO for the measurement of voltage (de and ac frequency, time period), special features of dual trace CRO, introduction to digital oscilloscope, Digital storage Oscilloscope: Block diagram and principle of working.

Practical:

The test of lab skills will be of the following test items:

1. Galvanometer/Voltmeter/Ammeter
2. Measurement of de voltage and dc current, ac voltage. ac current and electrical/electronic circuit element (resistance. diode, transistor etc.) their significance.
3. Use of wattmeter for power measurement
4. Use of an oscilloscope
5. CRO as a versatile measuring device
6. Use of digital multimeter/ VTVM for measuring voltages
7. Winding a coil/transformer
8. Balancing of bridges
9. Q-meter/ LCR meter
10. Preparation of extension board.
11. Soldering practices.
12. Fault diagnosis and repairing

Reference Books:

1. Theraja: A text book in Electrical Technology
2. MG Say: Performance and design of AC machines
3. Venugopal: Digital Circuits and systems
4. Shimon P. Vingron: Logic circuit design
5. Salivahanan & Kumar: Electronic Devices and circuits
6. U.Tietze, Ch.Schenk: Electronic circuits: Handbook of design and applications
7. Thomas L. Floyd: Electronic Devices

Course Outcomes:

On completion of the course, the students will be able to

CO1: Develop skill in handling common machine tools available in mechanical workshops.

CO2: Design printed circuit board as per the desired circuits.

CO3: Know the basics and perform electrical wirings.

CO4: Learn the working principle of digital meters, CRO and their use.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1	1								3	2	2	1
CO2	3	2	1	1	1								3	2	2	1
CO3	3	2	1	1	1								3	2	2	1
CO4	3	2	1	1	1								3	2	2	1

Physics Workshop Skill Credits: 2

Paper code: UG/SC/ SEC/PHY/ PR/02/B

Introduction: Measuring units: conversion to SI and CGS. Familiarization with meter scale, Vernier caliper. Screw gauge and their utility. Measure the definition of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet etc. Use of Sextant to measure height of buildings. mountains, etc.

Mechanical Skill Development: A Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining. forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron metal sheets. composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, sharper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block . Use of bench vice and tools for fitting. Make funnel using metal sheet.

Introduction to prime movers: Mechanism, gear system. wheel, Fixing of gears with motor axel. Lever mechanism. Lifting of heavy weight using lever. Braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment.

Reference Books:

1. Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.

2. Workshop Processes, Practices and Materials, Bruce J Black 2005. 3rd Ed. Editor

Newnes [ISBN :0750660732]

3. New Engineering Technology. Lawewnce Smyth/Liam Hennessy. The Educational

Company of Ireland [ISBN:0861674480]

Course Outcomes:
On completion of the course, the students will be able to

CO1: Utilize vernier calipers, screw gauge, secants to measure different physical quantities.

CO2: Get an overview of manufacturing methods

CO3: Acquire knowledge in handling common machine tools available in workshops.

CO4: Know the mechanism of gear systems, levers, brakes, power generation systems etc.

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	1	1	1				1				3	2	1	1
CO2	3	2	1	1	1				1				3	2	1	1
CO3	3	2	1	1	1				1				3	2	1	1
CO4	3	2	1	1	1				1				3	2	1	1