University of Kalyani

CURRICULUM & CREDIT FRAMEWORK

FOR

FOUR YEARS UNDER-GRADUATE PROGRAM IN PHYSICS

(HONOURS/ HONOURS WITH RESEARCH)

(Under NEP 2020)

With Effect from the Academic Session 2023-24

SEMESTER-I							
Course Code	Course Title (credit)	Nature of Course	Credit of Course	Class hours/ week	Evaluation		Total
					Internal	Semester End	
PHY-M-T-1	Mathematical physics I (4+2)	Major	6	6	15	60	75
PHY-M-P-1							
PHY-MI-T-1	Mathematical physics I (3+1)	Minor	4	4	10	40	50
PHY-MI-P-1							
PHY-MU-T-1	Physics in everyday life	Multidisciplinary Course	3	3	10	35	45
PHY-SEC-T-1	Electrical circuit and network skills	Skill Enhancement Course	3	3	10	35	45
		Value Added Course	4	4	10	40	50
			20	20	55	210	265

- Value Added Course will be common to all majors

SEMESTER-II							
Course Code	Course Title	Nature of Course	Credit of Course	Class hours/ week	Evaluation		Total
					Internal	Semester End	
PHY-M-T-2	Mechanics (4+2)	Major	6	6	15	60	75
PHY-M-P-2							
PHY-MI-T-2	Mathematical physics I (3+1)	Minor	4	4	10	40	50
PHY-MI-P-2							
PHY-MU-T-2	Physics in everyday life	Multidisciplinary Course	3	3	10	35	45
PHY-AECC-T-1		Ability Enhancement Course	4	4	10	40	50
PHY-SEC-T-2	Basic Instrumentation Skills	Skill Enhancement Course	3	3	10	35	45
For Certificate		Summer Internship	4*	4			
			20	20	45	220	265

- Ability Enhancement Course will be common to all majors.

*Additional for Certificate

SEMESTER-III							
Course Code	Course Title	Nature of Course	Credit of Course	Class hours/ week	Evaluation		Total
					Internal	Semester End	
PHY-M-T-3	Electricity and magnetism (4+2)	Major	6	6	15	60	75
PHY-M-P-3							
PHY-MI-T-3	Electricity and magnetism (3+1)	Minor	4	4	10	40	50
PHY-MI-P-3							
PHY-MU-T-3	Physics in everyday life	Multidisciplinary Course	3	3	10	35	45
PHY-SEC-T-3	Renewable Energy and Energy Harvesting	Skill Enhancement Course	3	3	10	35	45
		Value Added Course	4	4	10	40	50
			20	20	55	210	265

- Value Added Course will be common to all majors

SEMESTER-IV							
Course Code	Course Title	Nature of Course	Credit of Course	Class hours/ week	Evaluation		Total
					Internal	Semester End	
PHY-M-T-4	Wave Optics and Electromagnetic Theory (4+2)	Major	6	6	15	60	75
PHY-M-P-4							
PHY-M-T-5	Thermal Physics (4+2)	Major	6	6	15	60	75
PHY-M-P-5							
PHY-MI-T-4	Electricity and magnetism (3+1)	Minor	4	4	10	40	50
PHY-MI-P-4							
PHY-AECC-T-2		Ability Enhancement Course	4	4	10	40	50
For Diploma		Summer Internship	4**	4			
			20	20	50	200	250

- Ability Enhancement Course will be common to all major.

**Additional for Diploma

SEMESTER-V							
Course Code	Course Title	Nature of Course	Credit of Course	Class hours/ week	Evaluation		Total
					Internal	Semester End	
PHY-M-T-6	Classical and Statistical Mechanics (4+2)	Major	6	6	15	60	75
PHY-M-P-6							
PHY-M-T-7	Quantum Mechanics (4+2)	Major	6	6	15	60	75
PHY-M-P-7							
PHY-MI-T-5	Thermal and Statistical Physics (3+1)	Minor	4	4	10	40	50
PHY-MI-P-5							
OTH-MI-T-1	Minor from any other subject (4)	Minor	4	4	10	40	50
			20	20	50	200	250

SEMESTER-VI							
Course Code	Course Title	Nature of Course	Credit of Course	Class hours/ week	Evaluation		Total
					Internal	Semester End	
PHY-M-T-8	Electronics (4+2)	Major	6	6	15	60	75
PHY-M-P-8							
PHY-M-T-9	Solid state physics (4+2)	Major	6	6	15	60	75
PHY-M-P-9							
PHY-M-T-10	Mathematical Physics-II (4+2)	Major	6	6	15	60	75
PHY-M-P-10							
For B.Sc.(Hons)		Outreach/ Internship	2	2			
			20		45	180	225

SEMESTER-VII							
Course Code	Course Title	Nature of Course	Credit of Course	Class hours/ week	Evaluation		Total
					Internal	Semester End	
PHY-M-T-11 PHY-M-P-11	Classical and Statistical Mechanics –II (4+2)	Major	6	6	10+5	60	75
PHY-M-T-12 PHY-M-P-12	Quantum Mechanics–II (4+2)	Major	6	6	10+5	60	75
PHY-M-T-13 PHY-M-P-13	Electronics-II (4+2)	Major	6	6	10+5	60	75
PHY-MI-T-6 PHY-MI-P-6	Electronics (3+1)	Minor	4	4	10	40	50
OTH-MI-T-2	Minor from any other subject (4)	Minor	4	4	10	40	50
			26	26	65	260	325

SEMESTER-VIII							
Course Code	Course Title	Nature of Course	Credit of Course	Class hours/ week	Evaluation		Total
					Internal	Semester End	
PHY-M-T-14	Electrodynamics and Plasma (4)	Major	4	4	10	40	50
PHY-M-T-15	Nuclear and Particle Physics (4)	Major	4	4	10	40	50
PHY-M-P-16	Physics Practical (4)	Major	4	4	10	40	50
For B.Sc. Honours without Research Degree							
PHY-M-WR-T-1 PHY-M-WR-P-1	Adv. Mathematical Methods (4+2)	Major	6	6	15	60	75
PHY-M-WR-T-2 PHY-M-WR-P-2	Adv. Quantum Mechanics-II (4+2)	Major	6	6	15	60	75
For B.Sc. Honours with Research Degree							
PHY-M-R	Research Project/ Dissertation		12	12	Internal (Dept. Evaluation)	Semester End: Thesis Evaluation / PPT presentation & Viva	150
					30	80 / 40	
For B.Sc. Honours with or without Research Degree			48	48	60	240	300

Semester-I

MAJOR

PHY-M-T-1: MATHEMATICAL PHYSICS-I

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

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:

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order Differential Equations and Integrating Factor. (5 Lectures)

Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. (10 Lectures)

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. (5 Lectures)

Vector Calculus:

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. (6 Lectures)

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates. (7 Lectures)

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proof) (10 Lectures)

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. (4 Lectures)

Matrices:

Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew- Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Eigen-values and Eigenvectors (Degenerate and non-degenerate). Cayley-Hamiliton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary homogeneous Differential Equations. Functions of a Matrix. (6 Lectures)

Introduction to probability:

Independent random variables: Sample space and Probability distribution functions. Binomial, Gaussian, and Poisson distribution with examples. Mean and variance. (5 Lectures)

Dirac Delta function and its properties:

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. (2 Lectures)

Reference Books:

• Vector Analysis, S. Lipschutz, D. Spellman, M. R. Spiegel, Schaum's Outlines Series
• Fundamentals of Mathematical Physics, A.B. Gupta, Books & Allied Ltd; 5th edition
• Mathematical Physics, Goswami, 1st edition, Cengage Learning
• Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
• Higher Enginering Mathematics, B. S. Grewal, Khanna Publisher
• Play with Graphs, Amit M. Agarwal, Arihant Publisher
• Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
• Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
• Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.

PHY-M-P-1: MATHEMATICAL PHYSICS-I

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

- *The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.*
- *Highlights the use of computational methods to solve physical problems*
- *The course will consist of lectures (both theory and practical) in the Lab*
- *Evaluation done not on the programming but on the basis of formulating the problem*
- *Aim at teaching students to construct the computational problem to be solved*
- *Students can use any one operating system Linux or Microsoft Windows*

Introduction and Overview

Computer architecture and organization, memory and Input/output devices

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

Errors and error Analysis

Truncation and round off errors, Absolute and relative errors, Floating point computations.

Introduction to programming in Python/Fortran/Matlab/C/C++:

Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object-oriented programming.

Introduction to plotting graphs with Matplotlib/Gnu plot/Origin/Excel

Basic 2D and 3D graph plotting - plotting functions and datafiles, fitting data using gnuplot's fit function, polar and parametric plots, modifying the appearance of graphs, Surface and contour plots, exporting plots

Programming:

Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search, Factorial of a number, sum of a power series e.g. sin, cosine, exponential series etc.

Random number generation

Area of circle, area of square, volume of sphere, value of pi (π).

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods

Solution of linear and quadratic equation, solving, $\theta = \tan\theta$, $I = I_0\{\mathrm{Sin}\,\alpha/\alpha\}^2$ in optics

Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation

Evaluation of trigonometric functions e.g. $\sin\theta, \cos\theta, \tan\theta$ etc.

Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method

Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop. Monte-Carlo integration Curve fitting, Least square fit, Goodness of fit, standard deviation Ohms law to calculate R, Hooke's law to calculate spring constant.

Referred Books:

• Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
• Numerical Methods, Arun Kr Jalan, Utpal Sarkar, University Press
• Python Programming, Satyanarayana, Radhika Mani, Jagdesh, University Press
• Scientific Computing in Python, Abhijit Kar Gupta, Techno World
• Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
• Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn. , 2007, Cambridge University Press.
• A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
• Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. , 2007, Wiley India Edition.
• Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
• An Introduction to computational Physics, T.Pang, 2nd Edn. , 2006, Cambridge Univ. Press

MINOR

PHY- MI-T-1: MATHEMATICAL PHYSICS-I

Theory: (3 Credits) No. of Lectures - 45

Marks (Semester End - 30, Internal Assessment – 05)

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:

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order Differential Equations and Integrating Factor. (5 Lectures)

Second Order Differential equations:

Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. (10 Lectures)

Vector Calculus:

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. (6 Lectures)

Vector Differentiation:

Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates. (7 Lectures)

Vector Integration:

Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proof) (10 Lectures)

Matrices:

Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew- Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and

Unitary Matrices. Trace of a Matrix. Eigen-values and Eigenvectors (Degenerate and non-degenerate). (5 Lectures)

Dirac Delta function and its properties:

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. (2 Lectures)

Reference Books:

• Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
• Vector Analysis, S. Lipschutz, D. Spellman, M. R. Spiegel, Schaum's Outlines Series
• Fundamentals of Mathematical Physics, A.B. Gupta, Books & Allied Ltd; 5th edition
• Mathematical Physics, Goswami, 1st edition, Cengage Learning
• Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
• Higher Enginering Mathematics, B. S. Grewal, Khanna Publisher
• Play with Graphs, Amit M. Agarwal, Arihant Publisher
• Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
• Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
• Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press
• Undergraduate Physics Companion (Vol-1), S. Pal, 1st edition 2022, Suhrid Prakashani, Kolkata.

PHY-MI-P-1: MATHEMATICAL PHYSICS-I

Practical - (1 Credits) No. of Classes- 30

Marks: (Semester End – 10, Internal Assessment – 05)

Introduction to programming in Python/Fortran/Matlab/C/C++:

Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object-oriented programming.

Introduction to plotting graphs with Matplotlib/Gnuplot/Origin/Excel

Basic 2D and 3D graph plotting - plotting functions and datafiles, fitting data using gnuplot's fit function, modifying the appearance of graphs.

Programs:

Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search, Factorial of a number, sum of a power series e.g. sin, cosine, exponential series etc.

Random number generation

Area of circle, area of square, volume of sphere, value of pi (π),

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods

Solution of linear and quadratic equation, solving, $\theta = tan\ \theta$

Referred Books:

• Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
• Numerical Methods, Arun Kr Jalan, Utpal Sarkar, University Press
• Python Programming, Satyanarayana, Radhika Mani, Jagdesh, University Press
• Scientific Computing in Python, Abhijit Kar Gupta, Techno World
• Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
• Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn. , 2007, Cambridge University Press.
• A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
• Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. , 2007, Wiley India Edition.
• Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
• An Introduction to computational Physics, T.Pang, 2nd Edn. , 2006, Cambridge Univ. Press.

MULTIDISCIPLINARY COURSE

PHY-MU-T-1: PHYSICS IN EVERYDAY LIFE

Theory: (3 Credits) No. of Lectures – 45

Marks: (Semester End – 35, Internal Assessment – 10)

Internal Assessment [Class Attendance (Theory) - 05, Theory (Class Test/ Assignment/ Tutorial) - 05]

Course Description: This course aims to introduce the fundamental principles of physics and explore their applications in various aspects of everyday life. Students will develop an understanding of the physical laws governing the world around us and how they manifest in common phenomena and technologies by a qualitative approach.

Course Objectives:

- *To provide an overview of key physics concepts and principles.*
- *To demonstrate the relevance of physics in everyday life.*
- *To develop critical thinking skills in analysing and explaining real-world phenomena using physics principles.*
- *To foster an appreciation for the scientific method and the role of physics in advancing society.*

Introduction to Physics: Overview of Physics and its role in understanding the natural world. Scientific method and experimental design. Units and measurements. (6 Lectures)

Mechanics and Motion: Newton's laws of motion and their applications, Projectile motion, Forces in equilibrium, Friction and its effects, Physics of transportation and motion. (6 Lectures)

Energy and Its Transformations: Conservation of energy, Work and power, Potential and kinetic energy, Energy transfers and transformations, Physics in sports and recreational activities. (6 Lectures)

Waves and Sound: Properties of waves, Sound waves and their characteristics, Pitch, loudness, and the Doppler effect, Sound production and perception, Physics of music and musical instruments. (6 Lectures)

Light and Optics: Electromagnetic spectrum, Reflection, refraction, and diffraction, Lenses and optical instruments, Vision and the human eye. (6 Lectures)

Electricity and Magnetism: Electric charge and electric fields, Electric circuits and Ohm's law, Magnetism and magnetic fields, Electromagnetic induction. (6 Lectures)

Modern Physics: Atomic structure and quantum theory, Particle physics and the Standard Model. Nuclear physics and radioactivity, Applications of modern physics in technology. (9 Lectures)

(All the above topics will be taught in qualitative approach and with examples as much as possible)

Reference Books:

- Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
- Physics - Resnick, Halliday & Walker 9/e, 2010, Wiley
- Undergraduate Physics Companion (Vol-1), Dr. S. Pal, 1st edition, Suhrid Book Stall, Kolkata.
- Classical Mechanics and Properties of Matter, Gupta, Books and Allied (P) Ltd.
- Principles of Acoustics, Ghosh, Shreedhar Publisher.
- Snatak Padartha Bigyan (Part -1 & 2), Dasgupta, Book Syndicate
- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
- আধুনিক বিজ্ঞানের ক্রমবিকাশ, সম্পাদনা: সুশান্ত মজুমদার, ভূপতি চক্রবর্তী, অনুষ্টুপ প্রকাশ

Additional Books for Reference:

- Modern Atomic and Nuclear Physics, A. B. Gupta, Books & Allied Ltd; 2nd Revised edn.
- A Text Book On Light By B.Ghosh & K.G Mazumdar, Sreedhar Publishers
- Atomic Physics, Ghoshal, S. Chand
- Nuclear Physics, Ghoshal, S. Chand

SKILL ENHANCEMENT COURSES

PHY-SEC-T-1: ELECTRICAL CIRCUITS & NETWORK SKILLS

Theory: (3 Credits) No. of Lectures – 45)

Marks: (Semester End – 35, Internal Assessment – 10)

Internal Assessment [(Class Test/ Assignment/ quiz etc) - 10]

The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode.

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law, Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with digital multimeter (name of the circuit elements and their ranges), Analog voltmeter and analog ammeter. (10 Lectures)

Understanding Electrical Circuits: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources (principle of generation, output wave form, advantage of using three- phase). Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. (10 Lectures)

Generators and Transformers: DC Power sources (basic idea). AC and DC generators (basic principle of action). Inductance, capacitance, and impedance. Operation of transformers (Step-up and step-down). (6 Lectures)

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Speed & power of ac motor. (4 Lectures)

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers (half wave and full wave rectifier with L, C, L-C filter arrangement, regulation). Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources. (5 Lectures)

Electrical Protection: Relays, Fuses and disconnect switches, Working principle of Circuit breakers, Miniature circuit breaker and its types. (5 Lectures)

Electrical Wiring: Conduit wiring (basic idea of house hold wiring). Basics of wiring: Star and Delta Connections. Preparation of extension board, Wiring Materials (Basic information about the wiring components). (5 Lectures)

Reference Books:

- A text book in Electrical Technology - B L Theraja - S Chand and Co.
- Performance and design of AC machines - M G Say ELBS Edn.

- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

Semester-II

MAJOR

PHY-M-T-2: MECHANICS

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

Fundamentals of Dynamics: Reference frames. Inertial frames; Galilean transformations; Galilean invariance. Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket. (6 Lectures)

Work and Energy: Work and Kinetic Energy Theorem. Conservative 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. (4 Lectures)

Collisions: Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames. (3 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. (12 Lectures)

Elasticity: Relation between Elastic constants. Twisting torque on a Cylinder or Wire. (3 Lectures)

Fluid Motion: Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube. Euler's Equation. Bernoulli's Theorem. (2 Lectures)

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. (3 Lectures)

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). Physiological effects on astronauts. (6 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. (7 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. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. (4 Lectures)

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. Four Vectors (definition and examples only). (10 Lectures)

Reference Books:

- Mechanics and general properties of matter, Satyendra Nath Maiti and Debiprasad Roychoudhury, New age international.
- Mechanics through Problems, Dhiranjan Roy, Ananda Dasgupta, 2022, Techno World.
- Problems in General Physics, I E Irodov, Arihant Publications.
- Mechanics, Berkeley Physics, vol. 1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Undergraduate Physics Companion (Vol-1), S. Pal, 1st edition, Suhrid Prakashani, Kolkata

Additional Books for Reference

- Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
- University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
- Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

PHY-M-P-2: MECHANICS

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

List of Experiments: *(At least ten practicals have to be done from the above list.)*

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g
5. To determine the Moment of Inertia of a Flywheel/ a rigid body.
6. To determine g and velocity for a freely falling body using Digital Timing Technique
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. To determine the Young's Modulus of the material of a bar by flexure method
9. To determine the Modulus of Rigidity of a Wire by - Dynamic Method.
10. To determine the elastic Constants of a wire by Searle's method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.
13. To draw the frequency - resonance length curve of a sonometer wire and to determine an unknown frequency of a tuning fork
14. Measurement of coefficient of viscosity by Stoke's method.

Reference Books

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

MINOR

PHY- MI-T-2: MATHEMATICAL PHYSICS-I

Theory: (3 Credits) No. of Lectures - 45

Marks (Semester End - 30, Internal Assessment – 05)

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:

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order Differential Equations and Integrating Factor. (5 Lectures)

Second Order Differential equations:

Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. (10 Lectures)

Vector Calculus:

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. (6 Lectures)

Vector Differentiation:

Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates. (7 Lectures)

Vector Integration:

Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proof) (10 Lectures)

Matrices:

Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew- Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Eigen-values and Eigenvectors (Degenerate and non-degenerate). (5 Lectures)

Dirac Delta function and its properties:

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. (2 Lectures)

Reference Books:

• Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
• Vector Analysis, S. Lipschutz, D. Spellman, M. R. Spiegel, Schaum's Outlines Series
• Fundamentals of Mathematical Physics, A.B. Gupta, Books & Allied Ltd; 5th edition
• Mathematical Physics, Goswami, 1st edition, Cengage Learning
• Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
• Higher Enginering Mathematics, B. S. Grewal, Khanna Publisher
• Play with Graphs, Amit M. Agarwal, Arihant Publisher
• Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
• Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
• Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press
• Undergraduate Physics Companion (Vol-1), S. Pal, 1st edition 2022, Suhrid Prakashani, Kolkata.

PHY-MI-P-2: MATHEMATICAL PHYSICS-I

Practical - (1 Credits) No. of Classes- 15

Marks: (Semester End – 10, Internal Assessment – 05)

Introduction to programming in Python/Fortran/Matlab/C/C++:

Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object-oriented programming.

Introduction to plotting graphs with Matplotlib/Gnuplot/Origin/Excel

Basic 2D and 3D graph plotting - plotting functions and datafiles, fitting data using gnuplot's fit function, modifying the appearance of graphs.

Programs:

Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search, Factorial of a number, sum of a power series e.g. sin, cosine, exponential series etc.

Random number generation

Area of circle, area of square, volume of sphere, value of pi (π),

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods

Solution of linear and quadratic equation, solving, $\theta = tan\ \theta$

Referred Books:

• Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
• Numerical Methods, Arun Kr Jalan, Utpal Sarkar, University Press
• Python Programming, Satyanarayana, Radhika Mani, Jagdesh, University Press
• Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
• Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn. , 2007, Cambridge University Press.
• A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
• Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. , 2007, Wiley India Edition.
• Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
• An Introduction to computational Physics, T.Pang, 2nd Edn. , 2006, Cambridge Univ. Press.

MULTIDISCIPLINARY COURSE

PHY-MU-T-2: PHYSICS IN EVERYDAY LIFE

Theory: (3 Credits) No. of Lectures – 45

Marks: (Semester End – 35, Internal Assessment – 10)

Internal Assessment [Class Attendance (Theory) - 05, Theory (Class Test/ Assignment/ Tutorial) - 05]

Course Description: This course aims to introduce the fundamental principles of physics and explore their applications in various aspects of everyday life. Students will develop an understanding of the physical laws governing the world around us and how they manifest in common phenomena and technologies by a qualitative approach.

Course Objectives:

- *To provide an overview of key physics concepts and principles.*
- *To demonstrate the relevance of physics in everyday life.*
- *To develop critical thinking skills in analysing and explaining real-world phenomena using physics principles.*
- *To foster an appreciation for the scientific method and the role of physics in advancing society.*

Introduction to Physics: Overview of Physics and its role in understanding the natural world. Scientific method and experimental design. Units and measurements. (6 Lectures)

Mechanics and Motion: Newton's laws of motion and their applications, Projectile motion, Forces in equilibrium, Friction and its effects, Physics of transportation and motion. (6 Lectures)

Energy and Its Transformations: Conservation of energy, Work and power, Potential and kinetic energy, Energy transfers and transformations, Physics in sports and recreational activities. (6 Lectures)

Waves and Sound: Properties of waves, Sound waves and their characteristics, Pitch, loudness, and the Doppler effect, Sound production and perception, Physics of music and musical instruments. (6 Lectures)

Light and Optics: Electromagnetic spectrum, Reflection, refraction, and diffraction, Lenses and optical instruments, Vision and the human eye. (6 Lectures)

Electricity and Magnetism: Electric charge and electric fields, Electric circuits and Ohm's law, Magnetism and magnetic fields, Electromagnetic induction. (6 Lectures)

Modern Physics: Atomic structure and quantum theory, Particle physics and the Standard Model. Nuclear physics and radioactivity, Applications of modern physics in technology. (9 Lectures)

(All the above topics will be taught in qualitative approach and with examples as much as possible)

Reference Books:

- Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
- Physics - Resnick, Halliday & Walker 9/e, 2010, Wiley
- Undergraduate Physics Companion (Vol-1), Dr. S. Pal, 1st edition, Suhrid Book Stall, Kolkata.
- Classical Mechanics and Properties of Matter, Gupta, Books and Allied (P) Ltd.
- Principles of Acoustics, Ghosh, Shreedhar Publisher.
- Snatak Padartha Bigyan (Part -1 & 2), Dasgupta, Book Syndicate
- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
- আধুনিক বিজ্ঞানের ক্রমবিকাশ, সম্পাদনা: সুশান্ত মজুমদার, ভূপতি চক্রবর্তী, অনুষ্টুপ প্রকাশ

Additional Books for Reference:

- Modern Atomic and Nuclear Physics, A. B. Gupta, Books & Allied Ltd; 2nd Revised edn.
- A Text Book On Light By B.Ghosh & K.G Mazumdar, Sreedhar Publishers
- Atomic Physics, Ghoshal, S. Chand
- Nuclear Physics, Ghoshal, S. Chand

SKILL ENHANCEMENT COURSES

PHY-SEC-T-2: BASIC INSTRUMENTATION SKILLS

(Theory + Lab): (3 Credits) No. of Lectures – 45)

Marks: (Semester End – 35, Internal Assessment – 10)

Internal Assessment [(Class Test/ Assignment/ quiz etc) - 10]

The aim of this course is to course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.

Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. (6 Lectures)

Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance. (6 Lectures)

Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only- no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. (9 Lectures)

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Specialfeatures of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and working principles. (5 Lectures)

Signal Generators and Analysis Instruments: Block diagram, explanation and specificationsof low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. (5 Lectures)

Impedance Bridges & Q-Meters: Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & workingprinciples of a Q- Meter. Digital L C R bridges. (5 Lectures)

Digital Instruments: Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. (4 Lectures)

Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution. (5 Lectures)

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

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Laboratory Exercises:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistanceand high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/ universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope

2. Converting the range of a given measuring instrument (voltmeter, ammeter)

Reference Books:

- A text book in Electrical Technology - B L Theraja - S Chand and Co.
- Performance and design of AC machines - M G Say ELBS Edn.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
- Electronic Devices and circuits, S. Salivahanan& N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

Semester-III

MAJOR

PHY-M-T-3: ELECTRICITY AND MAGNETISM

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

Electric Field and Electric Potential:

Electric field: Electric field lines, Electric flux, Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. (6 Lectures)

Conservative nature of Electrostatic Field, Electrostatic Potential, Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. (6 Lectures)

Electrostatic energy of system of charges. 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-plate capacitor. Capacitance of an isolated conductor. Uniqueness theorem (statement) Method of Images and its application to: (l) Plane Infinite Sheet and (2) Sphere. (10 Lectures).

Dielectric Properties of Matter:

Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations Between E, P and D. Gauss' Law in dielectrics. (8 Lectures).

Magnetic Field:

Magnetic force between current elements 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) infinite straight wire, (2) infinite planar surface current (3) Solenoid and (4) Toroid.

Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. (9 Lectures)

Magnetic Properties of Matter:

Magnetization vector (M). Magnetic Intensity(H). Magnetic Susceptibility and permeability. Relation between B, H, M. B-H curve and hysteresis. (3 Lectures)

Electromagnetic Induction

Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. (5 Lectures)

Transients:

Growth and decay of currents and voltages in L-R, C-R and L-C-R circuits; electrical oscillations in L-C circuits. (2 Lectures)

Electrical Circuits:

AC Circuits: Kirchhoffs laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. (4 Lectures)

Network theorems:

Ideal Constant – voltage and Constant – current Sources. Network Theorems: The venin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. (4 Lectures)

Ballistic Galvanometer:

Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR. (3 Lectures)

Reference Books:

• Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw.
• Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
• Feynman Lectures Vol. 2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
• Electricity and Magnetism, J. H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
• Electricity and Magnetism, E. M. Purcell, 1986, McGraw-Hill Education.
• Elements of Electromagnetics, M. N. O. Sadiku,2010, Oxford University Press.

PHY-M-P-3: ELECTRICITY AND MAGNETISM

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

List of Experiments (Minimum 5 has to be carried out in the semester)

1. Use a Multimeter for measuring (a) Resistances, (b) A C and DC Voltages, (c) DC Current, (d) Capacitances and (e) Checking electrical fuses.
2. To study the characteristics of a series (a) RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength Bandits variation in a solenoid (determined B/dx).
7. To verify the Thevenin and Norton theorems.
8. To verify the Super position, and Maximum power transfer theorems.
9. To determine self-inductance of a coil by Anderson's bridge.
10. 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) Bandwidth.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer.
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by Absolute method.
16. To study the characteristics of a series LR Circuit.
17. Measurement of the resistance of a mirror galvanometer by the half deflection method and to determine its figure of merit.

Reference Books:

- Practical Physics Vol1, Vol2, B. Gosh, K. G. Majumder, Sreedhar Publisher
- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash & Ramakrishna,11th Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogbom, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.
- Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.

MULTIDISCIPLINARY COURSE

PHY-MU-T-3: PHYSICS IN EVERYDAY LIFE

Theory: (3 Credits) No. of Lectures – 45

Marks: (Semester End – 35, Internal Assessment – 10)

Internal Assessment [Class Attendance (Theory) - 05, Theory (Class Test/ Assignment/ Tutorial) - 05]

Course Description: This course aims to introduce the fundamental principles of physics and explore their applications in various aspects of everyday life. Students will develop an understanding of the physical laws governing the world around us and how they manifest in common phenomena and technologies by a qualitative approach.

Course Objectives:

- *To provide an overview of key physics concepts and principles.*
- *To demonstrate the relevance of physics in everyday life.*
- *To develop critical thinking skills in analysing and explaining real-world phenomena using physics principles.*
- *To foster an appreciation for the scientific method and the role of physics in advancing society.*

Introduction to Physics: Overview of Physics and its role in understanding the natural world. Scientific method and experimental design. Units and measurements. (6 Lectures)

Mechanics and Motion: Newton's laws of motion and their applications, Projectile motion, Forces in equilibrium, Friction and its effects, Physics of transportation and motion. (6 Lectures)

Energy and Its Transformations: Conservation of energy, Work and power, Potential and kinetic energy, Energy transfers and transformations, Physics in sports and recreational activities. (6 Lectures)

Waves and Sound: Properties of waves, Sound waves and their characteristics, Pitch, loudness, and the Doppler effect, Sound production and perception, Physics of music and musical instruments. (6 Lectures)

Light and Optics: Electromagnetic spectrum, Reflection, refraction, and diffraction, Lenses and optical instruments, Vision and the human eye. (6 Lectures)

Electricity and Magnetism: Electric charge and electric fields, Electric circuits and Ohm's law, Magnetism and magnetic fields, Electromagnetic induction. (6 Lectures)

Modern Physics: Atomic structure and quantum theory, Particle physics and the Standard Model. Nuclear physics and radioactivity, Applications of modern physics in technology. (9 Lectures)

(All the above topics will be taught in qualitative approach and with examples as much as possible)

Reference Books:

- Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.
- Physics - Resnick, Halliday & Walker 9/e, 2010, Wiley
- Undergraduate Physics Companion (Vol-1), Dr. S. Pal, 1st edition, Suhrid Book Stall, Kolkata.
- Classical Mechanics and Properties of Matter, Gupta, Books and Allied (P) Ltd.
- Principles of Acoustics, Ghosh, Shreedhar Publisher.
- Snatak Padartha Bigyan (Part -1 & 2), Dasgupta, Book Syndicate
- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
- আধুনিক বিজ্ঞানের ক্রমবিকাশ, সম্পাদনা: সুশান্ত মজুমদার, ভূপতি চক্রবর্তী, অনুষ্টুপ প্রকাশ

Additional Books for Reference:

- Modern Atomic and Nuclear Physics, A. B. Gupta, Books & Allied Ltd; 2nd Revised edn.
- A Text Book On Light By B.Ghosh & K.G Mazumdar, Sreedhar Publishers
- Atomic Physics, Ghoshal, S. Chand
- Nuclear Physics, Ghoshal, S. Chand

SKILL ENHANCEMENT COURSES

PHY-SEC-T-3: RENEWABLE ENERGY & ENERGY HARVESTING

(Theory): (3 Credits) No. of Lectures – 45)

Marks: (Semester End – 35, Internal Assessment – 10)

Internal Assessment [(Class Test/ Assignment/ quiz etc) - 10]

Fossil fuels and Alternate Sources of energy

Fossil fuels and nuclear energy, their limitations, need of renewable energy, non-conventional energy sources. (4 Lectures)

Solar energy

Solar energy, It's importance, storage of solar energy (Thermal storage and Electrical storage, Mechanical storage), solar pond (Basic idea), Principle of operation of non-convective solar pond, applications of solar pond, solar water heating, flat plate collector, solar cooker (basic idea, Design principle and Constructional details of box type solar cooker and its limitation), solar furnace, solar green-houses (basic idea, types and advantage), Solar Cell principle (No mathematical treatment), application of solar photovoltaic system, advantage and disadvantage of Photovoltaic solar energy conversion. (10 Lectures)

Wind Energy harvesting

Wind Energy harvesting; Fundamentals of Wind energy, Basic principle of wind energy conversion, power of wind, Forces on the blades and thrust on turbine, Basic components of a Wind Energy Conversion system, Advantage and disadvantage of Wind energy Conversion system (7 Lectures)

Ocean Energy

Ocean thermal energy conversion (OTEC) (basic idea), Open cycle OTEC system, Closed cycle OTEC system, Basic idea of Heat exchanger, Basic principle of tidal power, Basic idea about components of tidal power plant, Estimate of power in simple Single basin tidal system. (7 Lectures)

Geothermal Energy

Geothermal Energy: Geothermal energy (Basic idea), Geothermal sources, Hydrothermal resources (basic idea of vapour dominated system and liquid dominated system), Applications of geothermal energy, advantages and disadvantages of geothermal energy. (6 Lectures)

Hydro Energy

Hydro power resources, Types of hydroelectric project (Run-of-river schemes, Storage schemes, Pumped-Storage schemes, Low head power plant, Medium head power plant, High head power station), environmental impact of hydropower sources. (6 Lectures)

Piezoelectric Energy harvesting

Introduction, Physics and characteristics of piezoelectric effect (No mathematical treatment), materials used for piezoelectricity, recent applications of piezoelectric generators. (5 Lectures)

Reference Books and resources:

- Non-conventional energy sources-G. D Rai-Khanna Publishers, New Delhi
- Solar energy-M P Agarwal-S Chand and Co. Ltd
- Solar energy-Suhas P Sukhative Tata McGraw-Hill Publishing Company Ltd.
- Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.
- Dr. P Jayakumar, Solar Energy: Resource Assessment Handbook, 2009
- J. Balfour, M. Shawand S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
- https://www.yumpu.com/en/document/view/15174084/module-5-nptel
- https://nptel.ac.in/courses/103103206

Semester-IV

MAJOR

PHY-M-T-4: WAVE OPTICS and ELECTROMAGNETIC THEORY

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

Superposition of Two Waves

Standing (Stationary) Waves in a String: Fixed and Free Ends. 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. (6 Lectures)

Wave Optics

Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. (2 Lectures)

Interference

Division of amplitude and wave front. 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. Fabry-Perot interferometer. (4 Lectures)

Diffraction

Kirchhoff s Integral Theorem, Fresnel-Kirchhoff s Integral formula and its application to rectangular slit. (4 Lectures)

Fraunhofer diffraction

Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. (4 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, Fresnel diffraction pattern of a straight edge, a slit and a wire. (4 Lectures)

Maxwell Equations

Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field, Energy Density. (8 Lectures)

EM Wave Propagation in Unbounded Media

Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. (6 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. (6 Lectures)

Polarization of Electromagnetic Waves

Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. 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. 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. Bi-quartz polarimeter. (8 Lectures)

Reference Books

- A Text Book on Light, B. Ghosh, K.G. Mazumder, Sreedhar Publisher.
- Advanced Acoustics, D. P. Roychowdhury, Chayan Publisher
- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw- Hill.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill

PHY-M-P-4: WAVE OPTICS and ELECTROMAGNETIC THEORY

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

List of Experiments (Minimum 5 has to be carried out in the semester)

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify X^2 -T law.
2. Familiarization with: Schuster's focusing; determination of angle of prism and to determine refractive index of the Material of a prism using sodium source.
3. To draw the deviation - wavelength of the material of a prism and to find the wavelength of an unknown line from its deviation.
4. To determine wavelength of (1) Na source and (2) spectral lines of suitable source using plane diffraction grating.
5. To determine the dispersive power of the material of a prism using mercury source.
6. To determine wavelength of sodium light using Fresnel Bi-prism.
7. To determine wavelength of sodium light using Newton's Rings.
8. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
9. To determine dispersive power and resolving power of a plane diffraction grating.
10. To verify the law of Malus for plane polarized light.
11. To determine the specific rotation of sugar solution using Polarimeter.
12. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.

Reference Books:

- B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited.
- Advanced Practical Physics, Vol 1, B. Ghosh, K.G. Majumdar, Shreedhar Publishers.
- An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd.
- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.

- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

- Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
- Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
- Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

PHY-M-T-5: THERMAL PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

Introduction to Thermodynamics

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroeth 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. (10 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

Extensive and Intensive Thermodynamic Variables. 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) Tds Equations, (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. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. (7 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)Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der 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 Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling. (10 Lectures)

Reference Books:

- Thermal Physics, A. B. Gupta, Haripada Roy, Books & Allied Ltd
- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw- Hill.
- A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw- Hill
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, Blundell and Blundell, 2nd Ed., 2012, Oxford University Press.

PHY-M-P-5: THERMAL PHYSICS

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

List of Experiments (Minimum 5 has to be carried out in the semester)

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 Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).

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

Real Gases: Behaviour of Real Gases

6. Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 Gas. Critical
7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method,
8. Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature
9. Determination of the boiling point of a liquid by Platinum resistance thermometer
10. Determination of the melting point of a solid with a thermocouple.
11. Measurement of the coefficient of linear expansion of a solid using an optical lever.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H.T. Workshop, 1971, Asia Publishing House
- Advanced Practical Physics, Vol 1, B. Ghosh, K. G. Majumder, Sreedhar Publication
- An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal,1985, Vani Pub.

MINOR

PHY- MI-T-4: ELECTRICITY AND MAGNETISM

Theory: (3 Credits) No. of Classes - 45

Marks (Semester End - 30, Internal Assessment – 05)

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.

Electrostatics

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem-Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. (8 Lectures)

Electric potential as line integral of electric field, potential due to appoint charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. (6 Lectures)

Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. (8 Lectures)

Magnetism

Magnetostatics: Biot-Savart's law and its applications-straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia, para, and ferromagnetic materials. (10 Lectures)

Electromagnetic Induction

Faraday's Law of electromagnetic induction. Lenz's Law. Self-Inductance and Mutual Inductance. Inductance of single coil, Mutual Inductance of two coils. Energy stored in magnetic field. (6 Lectures)

Maxwell's equations and Electromagnetic wave propagation

Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization. (7 Lectures)

Reference Books

• Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw.
• Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
• Feynman Lectures Vol. 2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
• Electricity and Magnetism, J. H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
• Electricity and Magnetism, E. M. Purcell, 1986, McGraw-Hill Education.
• Elements of Electromagnetics, M. N. O. Sadiku,2010, Oxford University Press.

PHY-MI-P-4: ELECTRICITY AND MAGNETISM

Practical - (1 Credits) No. of Classes- 30

Marks: (Semester End – 10, Internal Assessment – 05)

List of Experiments (Minimum 5 has to be carried out in the semester)

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometen (i) Measurement of charge and current sensitivity, (ii) Measurement of CDR, (iii) Determine a high resistance by Leakage Method, (iv) To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength Bandits variation in a Solenoid (Determined B/dx)
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster's Bridge.
9. To verify the Thevenin and Norton theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems
11. Verification of Ohm's law with a tangent galvanometer.
12. Determination of the end corrections of a metre bridge and to measure the value of an unknown resistance incorporating end corrections.

Reference Books

- Practical Physics Vol1, Viol2, B. Ghosh, K.G. Majumder, Sreedhar Publisher
- Advanced Practical Physics for students, B. L. Flint and H. T. Workshop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed.,2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogbom, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal,1985, Vani Pub.

Semester-V

MAJOR

PHY-M-T-6: CLASSICAL and STATISTICAL MECHANICS

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

Classical Mechanics of Point Particles:

Basic ideas of functionals. Extremization of action as a fundamental principle in mechanics, Generalised coordinates and velocities. D'Alembert's Principle, Hamilton's Principle, Lagrangian and Euler-Lagrange equations. Applications to simple systems such as coupled oscillators, harmonic oscillators, simple and spherical pendulums. Motion under Central force, Cyclic coordinates. Symmetries and conservation laws. Legendre transformations and the Hamiltonian formulation of mechanics. Poisson brackets, Canonical equations of motion. Applications to simple systems. (24 Lectures)

Classical Statistics:

Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, 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. (15 Lectures)

Theory of Radiation:

Properties of Thermal Radiation. Blackbody Radiation. Spectral Distribution of Black Body Radiation. Ultraviolet Catastrophe, Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of Wien's Distribution Law, Wien's Displacement law from Planck's law. Rayleigh-Jeans Law, Stefan-Boltzmann Law, Kirchhoff's law of radiation, Saha's Ionization Formula (8 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. (7 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, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. (6 Lectures)

PHY-M-P-6: CLASSICAL and STATISTICAL MECHANICS

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

List of Experiments (Minimum 5 have to be carried out in the semester)

Use C/C++/Scilab/Fortran/Python/MATLAB for solving the problems based on Statistical Mechanics, like

1. Simulation of motion of a particle in 1D under a given force $F(x, t, v)$ with given initial condition and plotting (x, t), (x, v), (t, v).

2. Study of simple pendulum (x -t, v -t, x -v plot) using video analysis and modelling tool (Tracker software).

3. Plot Maxwell-Boltzmann distribution function versus temperature.

4. Write a program to flip a coin n times and count heads and tails.

5. Write a program to roll a dice and display the number.

6. Plot Planck's law for Black Body radiation and compare it with Wien's Law and the Rayleigh-Jeans Law at high temperature (room temperature) and low temperature.

7. Plot Specific Heat of Solids by comparing (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature (room temperature) and low temperature and compare them for these two cases

8. Plot Fermi-Dirac distribution function versus temperature.

9. Plot Bose-Einstein distribution function versus temperature.

PHY-M-T-7: QUANTUM MECHANICS

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

Description of Wave Function:

Description of a particle using wave packets. Spread of the Gaussian wave-packet for a free particle in one dimension. Properties of Wave Function, Continuity of wave function, boundary condition and emergence of discrete energy levels, Eigenvalues and Eigenfunctions. Fourier transforms, position and momentum space wavefunction. Position-Momentum uncertainty. (8 Lectures)

Time-dependent Schrodinger equation and Operators:

Time-dependent Schrodinger equation and dynamical evolution of a quantum state; Linearity and Superposition Principles; Position, momentum and Energy operators; commutator of position and momentum operators; Hermitian Operators, Expectation values of position and momentum operators. (7 Lectures)

Time-independent Schrodinger equation, Hamiltonian, and bound states in an arbitrary potential:

Time-independent Schrodinger equation and Hamiltonian operator: stationary states and energy eigenvalues and eigenfunctions of Hamiltonian operator; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; general solution of the time-dependent Schrodinger equation in terms of linear combinations of stationary states; Application to one dimensional square well potential of finite depth. (7 Lectures)

Eigenvalues and eigenfunctions of the simple 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. (5 Lectures)

Quantum theory of 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 time-independent Schrodinger equation in spherical polar coordinates. Separation of variables for a second-order partial differential equation. Radial equation for attractive Coulomb interaction - Hydrogen atom. Spherical Harmonics (Solution to Legendre differential equation). Shapes of the probability densities for ground & first excited states. Orbital angular momentum quantum numbers l and m; s, p, d shells. (7 Lectures)

Spectra of Hydrogen atom and its fine structure :

Formula for first order nondegenerate perturbative correction to the eigenvalue statement only. Spin-orbit interaction and relativistic correction to the kinetic energy and Darwin term. Fine structure of the hydrogen atom spectrum (Qualitative Discussion only). (5 Lectures)

Generalized Angular Momenta and Spin:

Generalized angular momentum. Electron's magnetic Moment and Spin Angular Momentum. **J = L + S**. Gyromagnetic Ratio, Bohr Magneton, and the Landé g factor. Energy associated with a magnetic dipole placed in a magnetic field. Larmor's Theorem. (7 Lectures)

Atoms in External Magnetic & Magnetic Fields:

Zeeman Effect: Normal and Anomalous Zeeman Effect; Stern-Gerlach Experiment; Paschen-Back and Stark Effect (Qualitative Discussion only). (6 Lectures)

Many electron atoms:

Identical particles; Symmetric & Antisymmetric Wave Functions. Pauli's Exclusion Principle, Periodic table. Fine structure. Spin-orbit coupling in atoms- L-S and J-J couplings; Spectral Notations for Atomic States. Term symbols. Spectra of Alkali Atoms (Na, etc.).

(8 Lectures)

PHY-M-P-6: QUANTUM MECHANICS

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

List of Experiments (Minimum 5 have to be carried out in the semester)

Use Fortran/Python/MATLAB/Octave/ C/C++/Scilab for solving the following problems based on Quantum Mechanics, like

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom: $\frac{d^2y}{dr^2} = \frac{2m}{\hbar^2}(E - V(r))y$, where $V(r)=-e^2/r$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is << -13.6 eV. Take e = 3.795 $(eVA)^{1/2}$, he = 1973 (eVA) and m = 0.511 × 10^6 eV/c^2.

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

$$\frac{d^2y}{dr^2} = \frac{2m}{\hbar^2}(E - V(r))y \text{ , where } V(r) = -\frac{e^2}{r}e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVA)^{1/2}$, m = 0.511 × 10^6 eV/c^2, and a = 3 A, 5 A, 7 A. In these units he = 1973 (eVA). 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: $d2y$

$$\frac{d^2y}{dr^2} = \frac{2m}{\hbar^2}(E - V(r))y \text{ , where } V(r) = \frac{1}{2}kr^2 + \frac{1}{3}kr^2$$

Convert to dimensionless variables. Plot the Ground and first exited state wave functions.

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

$$\frac{d^2y}{dr^2} = \frac{2m}{\hbar^2}(E - V(r))y \text{ , where } V(r) = D(e^{-2\alpha r'} - e^{-\alpha r'}),\ r' = (r - r_0)/r$$

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 =940×10^6 eV/c, D=0.755501 eV, α =1.44, r_0 = 0.131349A

Laboratory based experiments:

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.

6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting.

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

8. Quantum efficiency of CCD's.

Reference Books:

• Schaum's outline of Programming with C++. J.Hubbard, 2 0 0 0, McGraw-Hill Publication

• Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3 rd Edn., 2007, Cambridge University Press.

• An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press

• Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernandez.2014 Springer.

• Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.

• Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978- 6133459274

MINOR

PHY- MI-T-5: THERMAL PHYSICS

Theory: (3 Credits) No. of Classes - 45

Marks (Semester End - 30, Internal Assessment – 05)

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.

Laws of Thermodynamics:

Thermodynamic Description of the system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. (15 Lectures)

Thermodynamical Potentials:

Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for (C_P - C_V), C_P/C_V, TdS equations. (8 Lectures)

Kinetic Theory of Gases:

Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases. (7 Lectures)

Theory of Radiation:

Blackbody radiation, Spectral distribution, Concept of Energy density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law. (7 Lectures)

Statistical Mechanics:

Maxwell-Boltzmann law - distribution of velocity – Quantum statistics -Phase space - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics (8 Lectures)

PHY-MI-P-5: THERMAL PHYSICS

Practical - (1 Credits) No. of Classes- 30

Marks: (Semester End – 10, Internal Assessment – 05)

List of Experiments (Minimum 5 have to be carried out in the semester)

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.

2. Measurement of Planck's constant using black body radiation.

3. To verify the Stefan's Constant.

4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.

5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.

6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.

7. To determine the temperature coefficient of resistance by Platinum resistance thermometer.

8. To study the variation of thermo e.m.f across two junctions of a thermocouple with temperature.

9. To record and analyze the cooling temperature of a hot object as a function of time using a thermocouple and suitable data acquisition system

10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge.

Reference Books:

• Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.

• A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

• A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal, 1985, Vani Publication.

Semester-VI

MAJOR

PHY-M-T-8: ELECTRONICS

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

Semiconductor Diodes: P and N type semiconductors. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction.Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell. (4 Lectures)

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β, Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. (6 Lectures)

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers RC-coupled amplifier and its frequency response. (8 Lectures)

Feedback in Amplifiers & Oscillators: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.(6 Lectures)

Operational Amplifiers: Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. (1) Inverting and non-inverting amplifiers, (2) Adder, (3)Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.(10 Lectures)

Integrated Circuits (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. 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. (2 Lectures)

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. 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. (3 Lectures)

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. (4 Lectures)

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. (4 Lectures)

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors. (3 Lectures)

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. (4 Lectures)

Timers: IC 555: Block diagram and applications: Astable multivibrator and Monostable multivibrator. (2 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). (2 Lectures)

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.(2 Lectures)

Reference Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Fundamental Principles of Electronics, B Ghosh, 2nd ed, 2008, Books & Allied (P) Ltd.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
- Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

PHY-M-P-8:ELECTRONICS

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

List of Experiments

1. To study V-I characteristics of P-N junction diode, and / Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
5. To study the characteristics of a Bipolar Junction Transistor in CB configuration.
6. To design a Wien bridge oscillator for given frequency using an op-amp.
7. To design an inverting/non-inverting amplifier using Op-amp (741,351) for dc voltage of given gain and study its frequency response.
8. To add two dc voltages using Op-amp in inverting and non-inverting mode
9. To design a precision Differential amplifier of given I/O specification using Op-amp.
10. To investigate the use of an op-amp as an Integrator/Differentiator.
11. To verify and design AND, OR, NOT, XOR and using NAND gates.
12. To design a combinational logic system for a specified Truth Table.
13. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
14. To minimize a given logic circuit.
15. Half Adder, Full Adder and 4-bit binary Adder.
16. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
17. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
18. To build JK Master-slave flip-flop using Flip-Flop ICs

Reference Books:

•Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

•OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.

•Advanced Practical Physics (volume II), B. Ghosh, Shreedhar Publication

• An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd

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

PHY-M-T-9: SOLID STATE PHYSICS

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis - Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. (12 Lectures)

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical 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 Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis 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 Penny 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 Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation) (6 Lectures)

Reference Books:

•Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
•Solid State Physics, S O Pillai, New Age International Private Limited.
•Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India
•Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
•Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
•Solid State Physics, M.A. Wahab, 2011, Narosa Publications
•Solid State Physics, A J Dekker, Laxmi Publication

PHY-M-P-9: SOLID STATE PHYSICS

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

List of Experiments

1. Measurement of susceptibility of paramagnetic solution (Quinckfs Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR).
6. To determine the refractive index of a dielectric layer using SPR.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature by four- probe method (room temperature to 150 °C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample. 11. To measure the mutual inductance of two coaxial coils at various relative orientations using a ballistic galvanometer.
11. Verification of the inverse cube law for magnetic dipoles (study of the dependence of the field of a magnetic dipole on distance) and determination of the horizontal component of the earth's magnetic field by deflection and oscillation magnetometers.

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.

PHY-M-T-10: MATMATHEMATICAL PHYSICS-II

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

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. (10 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 Functions and Orthogonality. (18 Lectures)

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).(3 Lectures)
Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error.(3 Lectures)

Partial Differential Equations: Solutions to partial differential equations, using separation 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. (10 Lectures)

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. (16 Lectures)

Reference Books:

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

PHY-M-P-10: MATMATHEMATICAL PHYSICS-II

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

List of Experiments

Introduction to Numerical computation Numpy/Scipy/Matlab/Octave/ Scilab/Fortan/C/ C++

Uses in optimization and solution of differential equations. Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, Eigen values problems.
Solution of mesh equations of electric circuits (3 meshes)
Solution of coupled spring mass systems (3 masses)

Generation of Special functions using User defined functions
Generating and plotting Legendre Polynomials Generating and plotting Bessel function

Solve Ordinary Differential Equations (ODE) (1st and 2nd order Differential equation) by Euler, modified Euler and Runge-Kutta (RK) 2nd and 4th order methods

- ✓ Radioactive decay
- ✓ Current in LCR, RC, LC circuits with DC source and AC source.
- ✓ Newton's law of cooling
- ✓ Classical equations of motion (1st and 2nd order Differential Equations)
- ✓ Simple harmonic oscillator
- ✓ Damped, overdamped, critically damped harmonic oscillator.
- ✓ Undamped and damped forced harmonic oscillator
- ✓ Transient and Steady state solution of a forced harmonic oscillator

Also attempt some problems on differential equations like:

(i) Solve the coupled first order differential equations

$dy/dx = y + x - x^2$, $dy/dx = -x$

for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4. Plot x vs y for each of the four initial conditions on the same screen for 0 < t < 15.

(ii) The ordinary differential equation describing the motion of a pendulum is $\theta'' = -\sin\theta$. The pendulum is released from rest at an angular displacement a i.e. $\theta(0) = a$, $\theta'(0) = 0$

Use the RK4 method to solve the equation for a = 0.1, 0.5 and 1.0 and plot ɵ as a function of time in the range 0 < t < 8π. Also, plot the analytic solution valid in the small θ, $(\sin\theta \approx \theta)$.

Solve Partial Differential Equations (PDE) by Fixed difference method

a) Wave equation
b) Heat equation
c) Poisson equation
d) Laplace equation

Numerical computation using Python/MATLAB/Octave/Fortran/C/C++:

1. Dirac delta function: Calculate the integration

$$\int e^{\frac{-(x-2)^2}{2\sigma^2}} (x+3)dx$$ for σ =1, 0.1, 0.01 and show it tends to 5.00.

2. Write a program to calculate the sum $\sum_{n=1}^{\infty} 0.2^n$.
3. Evaluate the Fourier coefficients of a given periodic function (square wave).
4. Frobenius method and special functions: Verify the relation $\int_{-1}^{1} P_n(\mu)P_m(\mu) = \delta_{mn}$. Plot $P_n(x)$, $J_n(x)$
5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
7. Evaluation of trigonometric functions e.g. sin 6.
8. Given Bessel's function at N points find its value at an intermediate point.
9. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.
10. Compute the nth roots of unity for n = 2, 3, and 4.
11. Find the two square roots of -5+12j.
12. Integral transform: FFT of exp(-x).

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press.
- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernandez. 2014 Springer ISBN: 978-3319067896.
- Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
- Scilab (A free software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
- Publishing Physics in Laboratory including python Programming (Semester III), Mandal, Chowdhuri, Das, Das, Santra Publication.
- Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

Semester-VII

MAJOR

PHY-M-T-11 : CLASSICAL AND STATISTICAL MECHANICS -II
Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

- **Revision of classical mechanics**

Derive Euler-Lagrange from Principle of Least Action. Show equivalence between Lagrangian and Newtonian mechanics. Understand how to go from Lagrangian → Hamiltonian via Legendre transform. Explain Noether's theorem with at least one example (energy or momentum). Solve simple problems using generalized coordinates (e.g., pendulum, Atwood machine, particle in electromagnetic field). Know when to use Lagrangian vs Hamiltonian.(4 Lectures)

- **Canonical Transformation**

Equations of canonical transformation; generating functions; examples of canonical transformations; integral invariants of Poincare; Lagrange and Poisson brackets as canonical invariants; infinitesimal contact transformations; constants of motion and symmetry principles; generators of infinitesimal symmetry transformations. (4 Lectures)

- **Hamilton-Jacobi theory**

Hamilton's principal and characteristic functions; Hamilton Jacobi equations for these two functions; separation of variables in the Hamilton-Jacobi method (e.g. simple harmonic motion, Kepler problem etc)(6 Lectures)

- **Rigid body dynamics:**

Lagrange's equations of motion for a rigid body; Euler's theorem on the motion of a rigid body; infinitesimal rotations. Euler's equations of motion. Force free motion of a rigid body; heavy symmetrical top with one point fixed; precession and nutation; Larmor precession; gyroscope and asymmetrical top, condition for Fast and sleeping top. (8 Lectures)

- **Mechanics of Continuous Media:**

Transition from discrete to continuous systems; the Lagrangian formulation; stress energy tensor and conservation theorems; Hamiltonian formulation; Poisson brackets and momentum representation; examples. (8 Lectures)

- **Revision of statistical mechanics:**

Random Walk, phase space, phase points, Phase trajectory, Ensemble, Liouville's equation, Gibbs paradox; Free energy, entropy. Micro canonical, canonical and grand canonical ensembles. Partition function and statistical definition of thermodynamic quantities. (4 Lectures)

- **Density Matrix:**

Quantum mechanical and statistical averaging, quantum Liouville equation, Density matrix for stationary ensembles. Construction of density matrix, Polarization vector, Pure and Mixed states, Application to a free particle in a box, an electron in a magnetic field, beam of spin ½ particles. (8 Lectures)

- **Quantum Statistics: Fermi and Bose distributions:**

Quantum gas in equilibrium; quantum gases of elementary particles; number density and chemical potential; energy density, equation of state and different thermodynamic quantities; relativistic quantum gas; black body radiation and Planck's law; degenerate Bose gas; lattice specific heat and phonons; Bose condensation and super fluidity; degenerate Fermi gas; degeneracy pressure; specific heat of degenerate Fermi gas; Riemann's ξ and integrals of quantum statistics : relativistic degenerate electron gas; high temperature dense matter; white dwarfs and neutron stars. (10 Lectures)

- **Real Gas:**

Free energy; virial equation of state; second virial coefficient and Joule Thomson expansion; inversion temperature, model calculation and van der Waals equation of state. (3 Lectures)

- **Phase Transitions:**

Liquid-gas, order-disorder, ferroelectric and ferromagnetic transitions; critical points; Ehrenfest's classification; order parameter; continuous and discontinuous transactions; Landau's theory of continuous transitions; continuity of entropy; discontinuity of specific heat; singularities of order parameter and partition function; generalized susceptibility; mean field theory; critical exponents; scaling and fluctuations of order parameter. (5 Lectures)

Reference Books:

1. Goldstein, Poole and Safko: Classical Mechanics – Addison Wesley / Narosa.
2. Landau and Lifshitz : Mechanics – Pergamon.
3. Rana and Joag: Classical Mechanics – Tata-McGraw Hill.
4. Whittaker : Analytical Dynamics of Particles and Rigid Bodies – Cambridge.
5. Fetter and Walecka : Theoretical Mechanics of Particles and Continua – McGraw Hill.
6. RaychaudhuriA.K: Classical Mechanics – Oxford.

7. Simmons: Differential Equations – Tata-McGraw Hill.
8. Bhatia: Classical Mechanics – Narosa.
9. Landau and Lifshitz: Statistical Mechanics – Pergamon
10. Toda, Kubo and Saito: Statistical Physics – Springer Verlag.
11. Reif: Fundamentals of Statistical and Thermal Physics – McGraw Hill.
12. Pathria: Statistical Mechanics – Pergamon.
13. Ma: Statistical Mechanics – World Scientific.
14. Huang: Statistical Mechanics – John Wiley

PHY-M-P-11: Power Point Presentation and Grand Viva - (2 Credits)

Marks: Semester End – 20 (Presentation - 15, Viva-Voce-05)

Internal Assessment – 05 (Material Submission - 05)

List of Topics:

- Canonical transformations
- Hamilton-Jacobi theory
- Rigid body dynamics
- Mechanics of Continuous Media
- Random Walk 2D
- Density Matrices
- Real Gas
- Phase Transitions

PHY-M-T-12: QUANTUM MECHANICS -II

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

- **Linear Vector Space formulation:**

The Linear Vector Space, Dimension and Basis of a Vector Space, concept of state vectors, Time Evolution of the state vectors, basis functions, inner product; dual space; principle of superposition of states, change of basis, Ket vector and its characteristics, Bra vector and its characteristics, orthonormality, completeness condition and closure property.(8 Lectures)

- **Hilbert Space and operators:**

The Hilbert Space, linear Operators, Hermitian Adjoint, Hermitian operator, Time Evolution Operator, Fundamental postulates of Quantum mechanics, eigenvalue equation, Projection Operators, Commutator Algebra, Parity Operator, Uncertainty Relation between Two Operators, Functions of Operators, Expectation values, Square-Integrable Functions: Wave Functions, Eigenvalues and Eigen vectors of an Operator.(6 Lectures)

- **Representations:**

Representation in Discrete Bases, Representation in Continuous Bases, Matrix Representation of Kets, Bras, and Operators, Position Representation, Momentum Representation, Connecting the Position and Momentum Representations, Schrödinger Equation and Wave Packets, Stationary States: Time-Independent Potentials, the Conservation of Probability. (8 Lectures)

- **Schrödinger, Heisenberg and Interaction pictures:**

Introduction to the three representations; equation of motion in Schrödinger, Heisenberg and Interaction pictures; time translation operator. Time Evolution of Expectation Values. (10 Lectures)

- **Harmonic oscillator with operator algebra:**

Creation and annihilation operators, Oscillator algebra, Hamiltonian of harmonic oscillator in terms of creation and annihilation operators, Number operator, solution of energy eigenvalues, Selection rule, solution of wave functions, Coherent state, Coherent state as a normalized state, Coherent state is a state of minimum uncertainty product of position and momentum.(12 Lectures)

- **Rotations:**

Infinitesimal Rotations, Finite Rotations, Properties of the Rotation Operator, Euler Rotations, Angular momentum as generator of rotation, Representation of the Rotation Operator, Rotation Matrices and the Spherical Harmonics.(6 Lectures)

- **Angular Momentum:**

Introduction to Orbital Angular Momentum, General Formalism of Angular Momentum, Geometrical Representation of Angular Momentum, commutation rules; eigenvalues and eigen functions of angular momentums, Matrix Representation of Angular Momentum, Spin Angular Momentum, algebra of Pauli spin matrices; spin half particle in a magnetic field and spinors; properties of the spherical harmonics. Addition of Two Angular Momenta, General Formalism, Calculation of the Clebsch–Gordan Coefficients.(10 Lectures)

Reference Books:

1. Introduction to Quantum Mechanics, David J. Griffiths, Third edition, Cambridge University Press

2. Introductory Quantum Mechanics, Fourth edition, Richard L. Liboff, Pearson

3. Quantum Mechanics, Amit Goswami, Waveland Press

4. Quantum Physics" Robert Eisberg and Robert Resnick (John Wiley and sons).

5. Quantum Theory" D. Bohm (Prentice-Hall).

6) Quantum Mechanics Concepts and Applications, 2nd ed. , Nouredine Zettili, John Wiley & Sons, Ltd

PHY-M-P-12: Power Point Presentation and Grand Viva - (2 Credits)

Marks: Semester End – 20 (Presentation - 15, Viva-Voce-05)

Internal Assessment – 05 (Material Submission - 05)

List of Topics:

- Different types of operators
- Schrödinger, Heisenberg and Interaction pictures
- Harmonic oscillator with operator algebra
- Coherent state and its applications
- Properties of the Rotation Operator, Euler Rotations
- Matrix Representation of Angular Momentum
- Clebsch–Gordan Coefficients

PHY-M-T-13: Electronics -II

Theory: (6 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 5]

- **Power Circuits:**

Regulated power supply; basic concepts; series regulator using BJT and op- amp regulator; SMPS; D.C / D.C converter; Power control by SCR.(4 Lectures)

- **Integrated Circuit Fabrication:**

Monolithic Integrated-circuit technology, Planner process, fabrication of BJT, MOSFET, diodes, Integrated-circuit resistors, capacitors. (4 Lectures)

- **Semiconductor Devices:**

MOSFET, CMOS, Power MOS, UJT, SCR, triac, diac, IGBT. Operational Amplifiers: Instrumentation amplifiers, Practical integrator and differentiator, Log and anti-log amplifier, Multiplier and Divider, RC active filters-first and second order low pass and high pass filter, band pass and band elimination filter.(6 Lectures)

- **Network Analysis:**

Constant k low pass, high pass; band pass and band elimination filters, m derived filters, propagation constants, characteristic impedance for T and sections, neper and decibel.(4 Lectures)

- **Noise:**

Different sources of noise; signal to noise ratio; definition and calculation of noise figure. (4 Lectures)

- **Amplitude Modulation:**

basic concepts of modulation, sidebands; double sideband, single sideband and carrier suppressed mode of transmission; power relation; modulation index, typical circuits for generation and detection of amplitude modulated waves; envelope and average detection, generation and detection of suppressed carrier type AM signals. VSB AM and QAM technique in TV broadcasting.(10 Lectures)

- **Angle Modulation:**

Concepts of frequency and phase modulation, Frequency spectrum; bandwidth; reactance tube and p-n junction methods of generation of FM waves; Armstrong system; demodulation by staggered tuned and Foster Seeley discriminator circuits, equivalence between PM and FM.(4 Lectures)

- **Digital circuits:**

Encoders, Decoders, tri-state devices, A/D converters-parallel comparator, Successive Approximation, Dual-slope.(4 Lectures)

- **Elements of Microprocessors:**

Review of 8085 µP, functions of ALU, Flags, ALE and different registers; instruction set; Assembly language programming; machine cycle; op-code fetch, memory read, memory write and timing diagram; Memory: FF or Latch as storage elements; array of memory elements; addressing of registers; memory map and address lines, absolute and partial decoding and multiple address ranges.(10 Lectures)

- **Transmission Lines, Waveguides and Microwaves oscillators:**

Parallel wire and coaxial lines; transmission line equation; characteristic impedance; propagation constant; high frequency transmission lines; travelling wave interpretation; VSWR; Coefficient of reflection; principle of stub line matching; directional coupler; Rectangular waveguide; waveguide modes; resonant cavities; reflex klystron; magnetron.(10 Lectures)

References:

1. Malvino and Leach: Digital Principles and Applications – Tata McGraw Hill
2. Streetman : Solid State Electronic Devices – Prentice Hall India
3. Gaekwad : Op –Amps and Linear Integrated Circuits – Prentice Hall India
4. Taub and Schilling: Digital Integrated Electronics – McGraw Hill Kogakusha
5. Kennedy : Electronic Communication Systems – Tata McGraw Hill
6. D. Roy Chowdhuri and Jain, Linear Integrated Circuits, New Age International (P) Ltd.
7. Milman and Grable, Microelectronics. Tata McGraw-Hill
8. R P Jain, Modern Digital Electronics, Tata McGraw-Hill
9. D Ryder, Electronic Fundamentals and applications, PHI
10. J D Ryder, Networks, Lines and Fields, PHI
11. Gaonkar: Microprocessor Architecture, Programming and Applications with 8085, PRI
12. Roddy and Coolen, Electronic Communications, Pearson
13. Samuel Y. Liao, Microwave Devices and Circuits, Pearson
14. B. C. Sarkar and S. Sarkar, Analog Electronics, Damodar Prakashani

15. B. C. Sarkar and S. Sarkar, Digital Electronics
16. Ram: Fundamentals of Microprocessors and Microcomputers – D. Rai and Sons
17. Sarkar: Microwave Propagation and Technique – S. Chand

PHY-M-P-13: Electronics -II

Practical - (2 Credits) No. of Classes- 60

Marks: Semester End – 20 (Lab. Note Book - 05, Viva-Voce-05, Experiment -10)

Internal Assessment – 05 (Sessional Viva-voce)

List of Experiments (Minimum 5 has to be carried out in the semester)

1. Amplitude modulation and demodulation.
2. Design and study of astable multivibrator using 555 timer.
3. Studies on FET and MOSFET.
4. Design and study of monostable multivibrator using 555 timer.
5. Design and study of DAC/ADC.
6. To make a 4-bit shift register using Flip-Flop ICs.
7. To built a 4-bit counter using Flip-Flop ICs and study timing diagram.
8. Experiments on microprocessor (8085).

MINOR

PHY- MI-T-6: Electronics

Theory: (3 Credits) No. of Lectures - 45

Marks (Semester End - 30, Internal Assessment – 05)

Semiconductor Diodes: P and N type semiconductors. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Zener Diode and Voltage Regulation. (4 Lectures)

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β, Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. (6 Lectures)

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter, Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. (8 Lectures)

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance. Barkhausen's Criterion. (6 Lectures)

Operational Amplifiers: Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator. (10 Lectures)

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD. AND, OR and NOT Gates. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. (3 Lectures)

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Conversion of a Truth table into Equivalent Logic Circuit. (4 Lectures)

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors. (4 Lectures)

Reference Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Fundamental Principles of Electronics, B Ghosh, 2nd ed, 2008, Books & Allied (P) Ltd.

• Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
• Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
• Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
• OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
• Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
• Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
• Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

PHY-MI-P-6: ELECTRONICS

Practical - (1 Credits) No. of Classes- 30

Marks: (Semester End – 10, Internal Assessment – 05)

List of Experiments

1. To study V-I characteristics of P-N junction diode.
2. To study the V-I characteristics of a Zener diode.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the characteristics of a Bipolar Junction Transistor in CB configuration.
5. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain.
6. To design a non-inverting amplifier using Op-amp (741,351) for dc voltage of given gain.
7. To verify and design AND, OR, NOT, XOR and using NAND gates.

Reference Books:

•Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
•OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
•Advanced Practical Physics (volume II), B. Ghosh, Shreedhar Publication
• An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd
•Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
•Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson

MINOR

OTH- MI-T-II

Theory: (4 Credits) No. of Lectures - 45

Semester-VIII

MAJOR

PHY-M-T-14: Electrodynamics and Plasma

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

- **Electromagnetic Fields :**

Maxwell's equations & Poynting's theorem (mention only), Conservation of linear and angular momentum - Maxwell's stress tensor, scalar and vector potentials, gauge transformations- Lorentz gauge and Coulomb gauge, the inhomogeneous wave equations - solution of inhomogeneous wave equations by Green's function; retarded and advanced solutions; Multipole expansion of localized charge distributions, Magnetic monopole.(14 Lectures)

- **Multipole Radiations:**

Electric and magnetic dipole field and radiation of a localized oscillating source; Hertz potential and corresponding field equations; Multipole expansion of the electromagnetic field; Electric quadrupole radiations; Sources of multipole radiation-multipole moment.(8 Lectures)

- **Moving Charge:**

Lienard-Wiechert potentials, the field of a uniformly moving point charge; convection potential and virtual photons. (6 Lectures)

- **Radiation from an Accelerated Charge :**

Fields of an accelerated charge; angular and frequency distributions of the emitted radiation; special cases of acceleration-parallel and perpendicular (circular orbit) to velocity; Larmor's formula and its relativistic generalization; Bremsstrahlung; Cerenkov radiation; radiation reaction; electromagnetic mass.(12 Lectures)

- **Scattering:**

Radiation damping; scattering by a free electron; scattering and absorption of radiation by a harmonically bound electron; scattering of electromagnetic waves from a system of charges, coherent and incoherent Bragg diffraction.(10 lectures)

- **Magneto-hydrodynamics and Plasma Physics :**

Conducting fluid in a magnetic field; freezing in of lines of force; MHD equations; magnetic pressure; magnetic viscosity; pinch effect; Alfven waves; plasma oscillations; screened potential

and Debye length. (10 Lectures)

References:

1. Classical Electrodynamics – J. D. Jackson – John Wiley & Sons
2. Introduction to Electrodynamics – David J. Griffiths – Pearson Education / Addison-Wesley
3. The Classical Theory of Fields (Vol. 2) – L. D. Landau & E. M. Lifshitz – Pergamon Press / Butterworth-Heinemann
4. Electrodynamics of Particles and Plasmas – P. C. Clemmow & J. P. Dougherty – Addison-Wesley / Cambridge University Press (reprints)
5. Introduction to Plasma Physics – R. J. Goldston & P. H. Rutherford – Institute of Physics Publishing (IOP)
6. Principles of Plasma Electrodynamics – A. F. Alexandrov, L. S. Bogdankevich, A. A. Rukhadze – Springer-Verlag
7. Electrodynamics and Plasma Physics – Dr. Subhasish Chatterjee – Laxmi Publications

PHY-M-T-15: Nuclear and Particle Physics

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

- **Basic nuclear properties:**

Mass; Change; parity; isospin; binding energy; separation energy. Nuclear size: Rutherford scattering, electron scattering and form factors, charge density radius and potential radius, Wood-Saxon potential, experimental methods of determination. Static Electric and Magnetic Moments of a Nucleus; magnetic dipole and electric quadrupole moments. experimental determination. (6 Lectures)

- **Liquid Drop Model:**

Properties of the model; the semi-empirical mass formula and its application to considerations of nuclear stability, Degenerate Fermi Gas Model applications. Nuclear Disintegrations: Nuclear Emission: Penetration of potential barrier; nature of barrier for neutrons, protons and alpha particles; Gamow's theory of alpha disintegration and calculation of reduced widths and decay half-lives. Beta Decay- Fermi theory; Kurie plot. (10 Lectures)

- **Scattering Problem:**

Ionization formula, range-energy relationship, charged particle detectors, energy measurement and identification of charged particles n-p scattering at low energies; effective range formula and scattering length, shape-independent approximation; modification of effective range for deuteron bound state; scattering by hard sphere and finite square-well potential. p-p scattering at lowenergies; identity of particles, antisymmetrization of wavefunction; comparison with n-p scattering; interference between nuclear and Coulomb forces; effective range. n-n scattering; charge-independence and charge symmetry, mirror nuclei, exchange forces and saturation, repulsive core; Relative stability of the n-n, n-p, and p-p systems. (12 Lectures).

- **Structure of Complex Nuclei:**

Shell Model: Evidence of shell structure; magic numbers; effective single particle potentials (square-well and harmonic oscillator); extreme single- particle model- its successes and failures in predicting ground state spin, parity and magnetic moments; Nordheim's rules; Schmidt limits, anomalous magnetic moments of nucleons and qualitative discussions about their origin. Collective Model: Evidence of collective motion; nature of vibrational and rotational spectra;

qualitative discussion in terms of phonons and rigid rotators; quadrupole moments of deformed even-even nucleus. (12 Lectures)

- **Particle Physics:**

Brief history of particle discovery, Relativistic Kinematics and Mandelstam variables. parity; charge conjugation and charge parity; G-parity, time reversal invariance and the principle of detailed balance; CPT theorem (statement only) and its consequences; strangeness; Gell-Mann Nishijima formula,; hypercharge; measurement of charge, spin, parity, lifetime of pions and muons, Methods of determination of mass, spin, parity and other quantum numbers of other particles (Principles only). Quark structure of baryons and mesons; charm, beauty and truth prediction of ; mass formula; baryon and meson resonances , quarkonium; Pauli principle and the colour of quarks. Gluons as mediators in quark quark interaction. Role of Neutrino in parity non-conservation in beta decay, Different types of neutrinos. (20 lectures)

References:

1. M. K. Pal : Theory of Nuclear structure (EWA press)
2. Cohen : Concepts of Nuclear Physics (Tata McGraw Hill)
3. Wong : Introductory Nuclear Physics (Prentice Hall)
4. Blatt and Weiskopff : Theoretical Nuclear Physics (Dover)
5. Evans : The Atomic Nucleus (McGraw Hill)
6. Roy and Nigam : Nuclear Physics (New Age International)
7. S. N. Ghoshal : Nuclear Physics (S Chand Publication)
8. Preston and Bhaduri : Structure of the Nucleus (Levant Books)
9. Y.M. Jana : An Introduction to Nuclear Physics (Narosa, New Delhi)
10. Krane : Introductory Nuclear Physics (Wiley India, New Delhi).
11. Preston : Physics of the Nucleus (Addison Wesley)
12. Greiner and Maruhn : Nuclear Models (Springer).
13. Lilley : Nuclear Physics –Principles and Applications, (Wiley India).

PHY-M-P-16: Physics Practical

Practical - (4 Credits) No. of Classes- 60

Marks: Semester End – 40 (Lab. Note Book - 05, Viva-Voce-15, Experiment -20)

Internal Assessment – 10 (Sessional Viva-Voce)

List of Experiments (Minimum 5 (If more than 5 practical are in running condition if not then all) has to be carried out in the semester

Name of experiment

1. Determination of spot size and the angle of divergence of a given laser source.
2. Millikan Oil Drop Experiment – e/m of Electron
3. Particle size Measurement by diffraction of monochromatic LASER.
4. Study of dispersion relation of elastic waves in monatomic and diatomic lattices by using electrical analogue circuits
5. Study of Photoconductivity of Semiconductors.
6. Temperature coefficient of resistance of copper
7. Franck-Hertz Experiment: To determine the first excitation energy of Argon.
   OR, Verification of Bohr's atomic theory by Franck-Hertz Experiment
8. Two Probe Method for Resistivity Measurement
9. Determination of the refractive index of a given transparent thin film using Michelson interferometer. Or, Determination of the thickness of a thin film using Michelson interferometer.
10. Determination of Velocity of Ultrasonic Wave
11. Calibration of Condenser
12. Study the effect of magnetostriction of a given material
13. Propagation of EM waves in a transmission line – Lecher wire.
14. Study of elliptically polarised light.
15. Y and σ - Interference method (a) elliptical (b) hyperbolic fringes. To determine Y and σ of the material of the given specimen by observing the elliptical and hyperbolic fringes formed in an interference set up.
16. Measurement of the absorption coefficient of a material (supplied) using laser light.
17. Magnetic parameters of a magnetic material by hysteresis loop tracer.
18. Study of Molecular spectra of Iodine in absorption and determination of dissociation energy
19. Determination of Lande g-factor by ESR spectroscopy
20. Determination of numerical aperture, splice loss, and mode field diameter of an optical fiber.

For B.Sc. Honours without Research Degree

MAJOR

PHY-M-WR-T-1: ADVANCED MATHEMATICAL METHODS

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

- **Calculus of Residues:**

Residue and evaluation of residue; Cauchy's residue theorem; evaluation of definite integrals by the method of contour integration (including integration around branch cuts); evaluation of principal values of improper integrals; summation and inversion of series; partial fraction representation of meromorphic functions; infinite product representation of entire functions (Mittag Leffler Expansion).Analytic Continuation: Definition and some elementary theorems; Schwarz reflection principle; power series method of analytic continuation. Complex Mapping. Conformal Transformation. (14 Lectures)

- **Integral Transforms:**

Fourier transform, Laplace transforms; Parseval's theorem and convolution theorem; partial differential equation and its classification; Solution of partial and ordinary differential equation by above transformations. Green's Functions: Inhomogeneous differential equation (Poisson equations, wave equation, etc.); Green's Functions, definition and properties (for self adjoint differential operators only) computation of Green's function, direct computation, eigenfunction expansion, integral transform method. (14 Lectures)

- **Group Theory:**

Abstract groups: subgroups, classes, cosets, factor groups, permutation group, normal, subgroups, direct product of groups; Examples like square and equilateral triangle symmetry elements, Homomorphism & isomorphism. Representations: reducible and irreducible, unitary representations, Schur's lemma and orthogonality theorems, characters of representation, direct product of representations. (14 Lectures)

- **Tensors:**

Coordinate transformation, Jacobian determinant, definition of tensors; contravariant, covariant and mixed tensors; tensor algebra, Riemannian Geometry, signature requirement, metric tensor, invariant volume, associated tensors, parallel transport, covariant differentiation, Christoffel symbols; Geodesics, Ricci identity, Riemann – Christoffel curvature tensors, curved space, Bianchi identity,

Ricci tensor, vanishing of the curvature tensor as a condition of flatness. Gradient, divergence, curl and Laplacian in terms of tensors. (18 Lectures)

Reference Books:

1. Sokolnikoff : Tensor Analysis-Wiley Toppan
2. Lass : Vector and Tensors-McGraw Hill Kogakusha
3. Joshi :Matrices and Tensors-New Age International.
4. A.W. Joshi : Group theory.
5. Riley, Hobson and Bence Mathematical Methods for Physics and Engineering: A Comprehensive Guide.
6. Mathews and Walker: Mathematical Methods of Physics
7. Arfken and Weber: Mathematical methods for Physicists
8. Morse and Feshbach: Methods of Theoretical Physics
9. Pipes and Harvil: Applied Mathematics for Physicists and Engineers –
10. Harper: Introduction to Mathematical Physics
11. Courant and Hilbert: Methods of Mathematical Physics –John Wiley.
12. Smirnov: Course on Higher Mathematics

PHY-M-WR-P-1: Power Point Presentation and Grand Viva - (2 Credits)

Marks: Semester End – 20 (Presentation - 15, Viva-Voce-05)

Internal Assessment – 05 (Material Submission - 05)

List of Topics:

- Cauchy's residue theorem
- Schwarz reflection principle
- Application of Fourier transform in Physics
- Application of Laplace transforms in Physics
- Parseval's theorem and its application
- Green's function and its application
- Permutation group and cyclic notation
- Schur's lemma and orthogonality theorems
- Riemannian Geometry
- Metric tensor
- Parallel transport and covariant differentiation
- Gradient, divergence, curl and Laplacian in terms of tensors

PHY-M-WR-T-2: Adv. Quantum Mechanics

Theory: (4 Credits) No. of Lectures – 60

Marks (Semester End - 40, Internal Assessment – 10)

Internal Assessment: **10** [Class Attendance (Theory) - 05, Class Test/ Assignment/ Tutorial - 05]

- **Approximation methods:**

Variational method for stationary state problems; Time - independent perturbation theory -non-degenerate and degenerate cases; Time-dependent perturbation theory -transition amplitude; constant and harmonic perturbations; Fermi's golden rule; WKB approximation; Adiabatic and sudden approximations; Applications. (8 Lectures)

- **Scattering theory:**

Scattering amplitude; differential and total cross-sections; Scattering in a spherically symmetric potential partial -wave analysis; phase shift its evaluation; Born approximation; hard sphere scattering. (6 Lectures)

- **Symmetries:**

Symmetry operations as unitary and anti-unitary transformations; conservation laws from invariance principles; Discrete symmetries; reflection, inversion and parity; intrinsic parity; time reversal; Kramers degeneracy. (6 Lectures)

- **Quantum Computation:**

Bits and Qubits; Quantum Cryptography; Bloch sphere representation of a Qubit, Multiple Qubits; Quantum Circuits: Single Qubit Gates, Multiple Qubit Gates, Design of Quantum Circuits; Quantum Teleportation; Experimental realization of Quantum Teleportation; Quantum Computation; Logical Operations on Quantum Registers; A real Quantum Computer. (10 Lectures)

- **Relativistic Quantum Mechanics:**

Klein-Gordon Equation: Continuity equation and indefinite norm; free particle solutions; negative energy-momentum solutions and their interpretation, non-relativistic reduction and interpretation of Klein-Gordon equation; the charged Klein-Gordon field; the interaction of a spin-0 particle with an electromagnetic field; spin of the KG particle; invariance properties. (10 Lectures)

- **Dirac equation:**

Why Dirac equation. The conjugate Dirac equation; continuity equation; non-relativistic correspondence; spin; helicity and magnetic moment of the Dirac particle. Lorentz covariance for the Dirac particle; gamma matrices, their different representations and properties; bilinearcovariant; free particle solutions and their representation; negative energy solutions and hole theory; positron. (20 Lectures).

References:

1. David Griffiths: Introduction to Quantum Mechanics -Pearson Education
2. L. Schiff: Quantum Mechanics -McGraw Hill Kogakusha
3. E. Merzbacher : Quantum Mechanics -John Wiley
4. J. J. Sakurai : Modern Quantum Mechanics -Addison Wesley
5. Schwabl: Quantum Mechanics -Narosa
6. Bransden and Joachain : Introduction to Quantum Mechanics -Longmans
7. Landau and lifshitz : Quantum Mechanics -Pergamon
8. Davydov : Quantum Mechanics –Pergamon
9. Gasiorowicz: Quantum Physics -John Wiley
10. Baym : Lecture Notes on Quantum Mechanics -Benjamin
11. Schweber : Relativistic Quantum Field Theory -Harper and Row
12. Bjorken and Drell : Relativistic Quantum Mechanics -McGraw Hill
13. Greiner : Relativistic Quantum Mechanics -Springer.
14. Ghatak and Lokanathan : Quantum Mechanics, Theory and Applications –Macmillan
15. Quantum Computation and Quantum Information, M. A. Nielsen & I. Chuang, Cambridge University Press (2000)
16. G. Greenstein and A. G. Zajonc The Quantum Challenge Modern Research on the Foundations of Quantum Mechanics-Narosa Publishing House
17. J.Preskill, Notes on Quantum Computation.
18. Mikio Nakahara and Tetsuo Ohmi,"Quantum Computing", CRC Press (2008).

PHY-M-WR-P-2: Power Point Presentation and Grand Viva - (2 Credits)

Marks: Semester End – 20 (Presentation - 15, Viva-Voce-05)

Internal Assessment – 05 (Material Submission - 05)

- Approximation methods
- Scattering theory
- Symmetries
- Quantum Computation
- Relativistic Quantum Mechanics
- Klein-Gordon Equation
- Dirac equation
- Gamma Matrices

For B.Sc. Honours with Research Degree

PHY-M-R: Research Project/ Dissertation

(12 Credits)

Semester End – 120

Internal Assessment – 30

Internal Assessment: **30** [Project guide Assessment-10 + Departmental Assessment (Two power point presentation regarding the progress of the project (no external examiner needed): 10+10]

Semester End: 120 [Submission and Evolution of project or dissertation thesis (Must be evaluated by external examiner) 60 + Power Point Presentation (In the Presence of External Examiner) - 30 + viva (In the presence of external examiner) -30]