UNIVERSITY DEPARTMENT OF PHYSICS

DR. SHYAMA PRASAD MUKHERJEE UNIVERSITY

PROPOSED YEAR WISE STRUCTURE & SYLLABUS OF

FOUR YEAR UNDER GRADUATE PROGRAM IN PHYSICS

UNDER

NEW EDUCATION POLICY 2020

SESSION: 2023-27 AND ONWARDS

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Amrutraj Mahale
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HIGHLIGHTS AND REGULATIONS OF FOUR YEAR U.G. PROGRAM IN PHYSICS

COURSES OF STUDY:

Courses of the study indicate pursuance of study in a Physics. Every discipline shall offer four categories of courses of study, viz. Major Paper (MJ) courses, Minor Course (MN), Skill Enhancement Courses (SEC) and Minor Vocational (MVC). Besides these four courses, a student will select Ability Enhancement Courses (AECs) and Value-Added Courses (VACs) from the respective pool of courses offered by the University.

a) **Major Paper (MJ)**: Major Paper is a course of study, which should be pursued by a student as a mandatory requirement of his/ her programme of study. In Bachelor of Science (Hons.) Physics programme, MJs are the core credit courses of Physics which will be appropriately graded and arranged across the semesters of study, being undertaken by the student, with multiple exit options as per NEP 2020.

b) **Minor Paper (MN):** The Minor course (MN) are a pool of credit courses of Physics from which a student with major other than physics will choose to study based on his/ her interest.

c) **Minor (vocational) Paper (MVC):** Minor vocational is a pool of courses offered by Physics which is meant to provide multidisciplinary or interdisciplinary education to students. A student has to opts for MNVs beyond his/ her discipline specific course(s) of study.

d) **Ability Enhancement course (AEC), Skill Enhancement Course (SEC) and Value Addition Course (VAC):** These three courses are a pool of courses offered by all the Departments in groups of odd and even semesters from which a student can choose.

   I. **AEC:** AEC courses are the courses based upon the content that leads to knowledge enhancement through various areas of study. They are based on Language and Literature, and Environmental Science which are mandatory for all disciplines.

   II. **SEC:** SECs are skill-based courses in all disciplines and are aimed at providing hands-on training, competencies, proficiency and skills to students. SEC courses may be chosen from a pool of courses offered by parent Department designed to provide skill-based instruction.

   III. **VAC:** VACs are common pool of courses offered by different disciplines and aimed towards personality building, embedding ethical, cultural and constitutional values; promote critical thinking, Indian knowledge systems, scientific temperament, communication skills, creative writing, presentation skills, sports and physical education and team work which will help in all round development of students.

PROGRAMME OVERVIEW/SCHEME OF PROGRAMME

Undergraduate degree programme of either 3 or 4-year duration, with multiple entries and exit points and re-entry options within this period, with appropriate certifications such as:

- A Certificate after completing 1 year (2 Semesters) of study in the chosen field of study.
- A Diploma after completing 2 years (4 Semesters) of study in the chosen field of study.
- A Bachelor's Degree after completing 3 years (6 Semesters) of study in the chosen field of study.
- A bachelor's Degree with Hons. / Research after completing 4 years (8 Semesters) of study in the chosen field of study.

COURSE STRUCTURE FOR FOUR YEAR UNDER UNDERGRADUATE PROGRAM **'HONOURS/RESEARCH'**

Credit Framework for Four Year Undergraduate Program under State Universities of Jharkhand [Total Credits=160]

Level of Courses	**Semester**	**MJ:** Discipline Specific Courses-Core or Major	**MN:** Minor from Discipline (16)	**MVC:** Minor from Vocational (16)	**MDC:** Multidisciplinary Courses (9)	**AEC:** Ability Enhancement Courses (Modern Indian Languages and English) (8)	**SEC:** Skill Enhancement Courses (9)	**VAC:** Value Added Courses (6)	**IAP:** Internship / Dissertation (4)	**RC:** Research Courses (12)	**AMJ:** Advanced Courses in lieu of Research (12)	**Credits**
1	2	3	4	5	6	7	8	9	10	11	12	13
Foundation or Introductory Courses	**I**	4	4		3	2	3	4				**20**
	II	4+4		4	3	2	3					**20**
	Exit Point: Undergraduate Certificate provided with Summer Internship/ Project (4 Credits)											
Intermediate - Level Courses	**III**	4+4	4		3	2	3					**20**
	IV	4+4+4		4		2		2				**20**
	Exit Point: Undergraduate Diploma provided with Summer Internship in 1^{st} *or* 2^{nd} / Project (4 Credits)											
Higher – Level Courses	**V**	4+4+4	4						4			**20**
	VI	4+4+4+4		4								**20**
	Exit Point: Bachelor's Degree											
Advanced Courses	**VII**	4+4+4+4	4									**20**
	VIII	4		4						12	4+4+4	**20**
	Exit Point: Bachelor's Degree with Hons. / Hons. With Research											**160**

Note: Honours students not undertaking research will do 3 courses for 12 credits in lieu of a research Project / Dissertation.

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COURSES OF STUDY FOR FOUR YEAR UNDERGRADUATE PROGRAMME

Semester wise Course Code and Credit Points for Single Major

Semester	Common, Introductory, Major, Minor, Vocational &Internship Courses		Credits
	Code	Papers	
I	AEC-101T	Hindi Language	2
	VAC-101T	Value Added Course-1	2
	VAC-102T	Value Added Course-2	2
	SEC-101T/ SEC-101P	Skill Enhancement Course-1	3
	MDC-101T/ MDC-101P	Multi-Disciplinary Course-1	3
	MN-101T/ MN-101P	Minor From Discipline-1	4
	MJ-101T/ MJ-101P	Major Paper-1(Disciplinary / Interdisciplinary Major)	4
II	AEC-201T	English Language	2
	SEC-201T/ SEC-201P	Skill Enhancement Course-2	3
	MDC-201T/ MDC-201P	Multi-Disciplinary Course-2	3
	MVC-201T/ MVC-201P	Minor From Discipline-2(Vocational Studies)	4
	MJ-201T/ MJ-201P	Major Paper-2(Disciplinary / Interdisciplinary Major)	4
	MJ-202T/ MJ-202P	Major Paper-3(Disciplinary / Interdisciplinary Major)	4
III	AEC-301T	Language and Communication Skills (MIL-2; Modern Indian Language including TRL)	2
	SEC-301T/ SEC-301P	Skill Enhancement Course-3	3
	MDC-301T/ MDC-301P	Multi-Disciplinary Course-3	3
	MN-301T/ MN-301P	Minor From Discipline-1	4
	MJ-301T/ MJ-301P	Major Paper-4(Disciplinary / Interdisciplinary Major)	4
	MJ-302T/ MJ-302P	Major Paper-5(Disciplinary / Interdisciplinary Major)	4
IV	AEC-401T	Language and Communication Skills (MIL-2; Modern Indian Language including TRL)	2
	VAC-401T	Value Added Course-3	2
	MVC-401T/ MVC-401P	Minor From Discipline-2 (Vocational Studies)	4
	MJ-401T/ MJ-401P	Major Paper-6(Disciplinary / Interdisciplinary Major)	4
	MJ-402T/ MJ-402P	Major Paper-7(Disciplinary / Interdisciplinary Major)	4
	MJ-403T/ MJ-403P	Major Paper-8(Disciplinary / Interdisciplinary Major)	4

Semester	Common, Introductory, Major, Minor, Vocational &Internship Courses		Credits
	Code	Papers	
V	MN-501T/ MN-501P	Minor From Discipline-1	4
	MJ-501T/ MJ-501P	Major Paper-9 (Disciplinary / Interdisciplinary Major)	4
	MJ-502T/ MJ-502P	Major Paper-10(Disciplinary / Interdisciplinary Major)	4
	MJ-503T/ MJ-503P	Major Paper-11(Disciplinary / Interdisciplinary Major)	4
	INT-501P/ APP-501P/ PRO-501P	Internship/Apprenticeship/ Field Work/Dissertation/ Project	4
VI	MVC-601T/ MVC-601P	Minor From Discipline-2 (Vocational Studies)	4
	MJ-601T/ MJ-601P	Major Paper-12(Disciplinary / Interdisciplinary Major)	4
	MJ-602T/ MJ-602P	Major Paper-13(Disciplinary / Interdisciplinary Major)	4
	MJ-603T/ MJ-603P	Major Paper-14(Disciplinary / Interdisciplinary Major)	4
	MJ-604T/ MJ-604P	Major Paper-15(Disciplinary / Interdisciplinary Major)	4
VII	MN-701T/ MN-701P	Minor From Discipline-1	4
	MJ-701T/ MJ-701P	Major Paper-16(Disciplinary / Interdisciplinary Major)	4
	MJ-702T/ MJ-702P	Major Paper-17(Disciplinary / Interdisciplinary Major)	4
	MJ-703T/ MJ-703P	Major Paper-18(Disciplinary / Interdisciplinary Major)	4
	MJ-704T/ MJ-704P	Major Paper-19(Disciplinary / Interdisciplinary Major)	4
VIII	MVC-801T/ MVC-801P	Minor From Discipline-2 (Vocational Studies)	4
	MJ-801T/ MJ-801P	Major Paper-20(Disciplinary / Interdisciplinary Major)	4
	RC-801T/ RC802T/ RC-803T	Research Internship/ Field Work/ Dissertation OR	12/
	AMJ-801T/ AMJ-801P	Advanced Major Paper-1(Disciplinary / Interdisciplinary Major)	
	AMJ-802T/ AMJ-802P	Advanced Major Paper-2(Disciplinary / Interdisciplinary Major)	4
	AMJ-803T/ AMJ-803P	Advanced Major Paper-3(Disciplinary / Interdisciplinary Major)	4 4
		Total Credit	**160**

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I. Major Papers of Four (04) credits each

Semester	Paper code	Course Title (Credit)	
Semester 1	PHY-MJ-101T/ PHY-MJ-101P	Mechanics (3T+1P Credits)	
Semester 2	PHY-MJ-201T/ PHY-MJ-201P	Mathematical Physics-I (3T+1P Credits)	
	PHY-MJ-202T/ PHY-MJ-202P	Current Electricity (3T+1P Credits)	
Semester 3	PHY-MJ-301T/ PHY-MJ-301P	Heat and Thermodynamics (3T+1P Credits)	
	PHY-MJ-302T/ PHY-MJ-302P	Wave and oscillations (3T+1P Credits)	
Semester 4	PHY-MJ-401T/ PHY-MJ-401P	Optics (3T+1P Credits)	
	PHY-MJ-402T/ PHY-MJ-402P	Electrostatics and Magnetism (3T+1P Credits)	
	PHY-MJ-403T/ PHY-MJ-403P	Mathematical Physics II (3T+1P Credits)	
Semester 5	PHY-MJ-501T/ PHY-MJ-501P	Analog Electronics (3T+1P Credits)	
	PHY-MJ-502T/ PHY-MJ-502P	Electromagnetic Theory (3T+1P Credits)	
	PHY-MJ-503T/ PHY-MJ-503P	Classical Mechanics (3T+1P Credits)	
Semester 6	PHY-MJ-601T/ PHY-MJ-601P	Relativity (3T+1P Credits)	
	PHY-MJ-602T/ PHY-MJ-602P	Digital Electronics (3T+1P Credits)	
	PHY-MJ-603T/ PHY-MJ-603P	Basic Quantum Mechanics (3T+1P Credits)	
	PHY-MJ-604T/ PHY-MJ-604P	Material Characterisation Techniques (3T+1P Credits)	
Semester 7	PHY-MJ-701T/ PHY-MJ-701P	Atomic and Molecular Physics (3T+1P Credits)	
	PHY-MJ-702T/ PHY-MJ-702P	Solid State Physics (3T+1P Credits)	
	PHY-MJ-703T/ PHY-MJ-703P	Statistical Mechanics (3T+1P Credits)	
	PHY-MJ-704T/ PHY-MJ-704P	Advanced Quantum Mechanics (3T+1P Credits)	
Semester 8	PHY-MJ-801T/ PHY-MJ-801P	Nuclear and Particle Physics (3T+1P Credits)	
	PHY-AMJ-801T/PHY-AMJ-801P or PHY- RC- 801T	Modern Optics (3T+1P Credits)	Research Methodology (4 Credits)
	PHY-AMJ-802T/PHY-AMJ-802P or PHY- RC- 802T	Nano Science & Technology (3T+1P Credits)	Research Proposal (4 credits)
	PHY-AMJ-803T/PHY-AMJ-803P or PHY- RC- 803T	Semiconductor devices (3T+1P Credits)	Research Report (4 credits)

Semester I

Mechanics (3 Credits)
Paper-PHY-MJ-101T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Fundamentals of Dynamics: Reference frames, Inertial frames, Review of Newton's Laws of Motion, Dynamics of a system of particles, Centre of Mass, Principle of conservation of linear momentum, Impulse, Momentum of variable-mass system: motion of rocket.

Rotational Dynamics: Angular momentum of a particle and system of particles, Torque, Principle of conservation of angular momentum, Moment of Inertia, Calculation of moment of inertia for rectangular, cylindrical and spherical bodies, Kinetic energy of rotation, Motion involving both translation and rotation.

Elasticity: Elastic constants and interrelation between them, Twisting torque on a Cylinder or Wire and twisting couple.

Flexure of beam: Bending of beam, Cantilever.

Surface Tension: Ripples and Gravity waves, Determination of Surface Tension by Jaeger's and Quinke's methods, Temperature dependence of Surface Tension.

Fluid Motion: Poiseuille's Equation for flow of a Liquid through a Capillary Tube and the corrections.

Central Force Motion: Motion of a particle under a central force field, Two-body problem: its reduction to one-body problem and solution, Kepler's Laws, Weightlessness.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
5. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. D.S. Mathur, P.S. Hemne, "Mechanics", S. Chand Publishing, 1981, 3e

PHYSICS LAB- PHY-MJ-101P (1 credit) FM: 25

1. Measurements of length (or diameter) using vernier caliper.
2. Measurements of length (or diameter) using screw gauge.
3. Measurements of length (or diameter) using travelling microscope.
4. To study the random error in observations.
5. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
6. To determine the Moment of Inertia of a Flywheel.
7. To determine the Modulus of Rigidity of a bar by method of bending.
8. To determine the elastic Constants of a wire by Searle's method.
9. To determine the value of g using Bar Pendulum.
10. To determine the value of g using Kater's Pendulum.

Semester II
Mathematical Physics-I (3 Credits)
Paper- PHY-MJ-201T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Calculus: First Order Differential Equations and Integrating Factor. Second Order Differential equations: Homogeneous Equations with constant coefficients, Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral for typical source terms like polynomials, exponential, sine, cosine etc. Calculus of multivariable functions: Partial derivatives, exact differentials. Integrating factor, with simple illustration.

Vector Calculus: Recapitulation of vectors: Properties of vectors under rotations, scalar productand its invariance under rotations. Vector product, Scalar triple product and their geometrical interpretation. Scalar and Vector fields.

Vector Differentiation: Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

Vector Integration: Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications. Dirac Delta function and its properties:

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Expression for Gradient, Divergence, Curl and Laplacian in orthogonal curvilinear co-ordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

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

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn.,Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
6.

PHYSICS LAB- PHY-MJ-201P (1 credit) FM:25

Topics	Description with Applications
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.
Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects
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
Random number generation	Area of circle, area of square, volume of sphere, value of π

Also attempt some problems on differential equations like:

1. Solve the coupled first order differential equations

$$\frac{dx}{dt} = y + x - \frac{x^3}{3}$$

$$\frac{dy}{dt} = -x$$

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 $0 \le t \le 15$.

2. The ordinary differential equation describing the motion of a pendulum is
$\vartheta'' = -\sin(\vartheta)$
The pendulum is released from rest at an angular displacement α i.e. $\vartheta(0) = \alpha$, $\vartheta'(0) = 0$. Use the RK4 method to solve the equation for α = 0.1, 0.5 and 1.0 and plot ϑ as a function of time in the range $0 \le t \le 8\pi$. Also, plot the analytic solution valid in the small ϑ ($\sin\vartheta \approx \vartheta$).
3. Solve the differential equation:

$$x^2\frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$$

with the boundary conditions: at x = 1, $y = (1/2)e^2$, $dy/dx = -(3/2)e^2 - 0.5$, in the range $1 \le x \le 3$. Plot y and dy/dx against x in the given range. Both should appear on the same graph.

Semester II
Current Electricity (3 Credits)
Paper- PHY-MJ-202T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

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) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential.Magnetic Force on (1) on point charge (2) on current carrying wire (3) between current elements.

DC circuits: growth and decay of current in CR and LR circuits, Growth and decay of currents in Series LCR circuit.

AC Circuits: AC Circuits: Kirchhoff's 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.

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Logarithmic damping.

AC bridges; Anderson's, Owen's, Schering and Carey-Foster's bridges with their vector diagrams.

Network theorems: 2-port network and its T and π representations, T and π equivalence, h-parameters representations, Thevenin, Norton, Superposition, Reciprocity and Maximum power transfer theorems, Miller theorem.

Reference Books:

1. Electricity, Tayal D. C.
2. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury,
3. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
4. Electricity and Magnetism, Chattopadhyaya and Rakshit
5. Electricity and Magnetism, Mahajan and Rangwala
6. Electricity and Magnetism, K. K. Tewary.

PHYSICS LAB- PHY-MJ-202P (1 credit) FM: 25

1. To verify the Thevenin and Norton theorems.
2. To verify the Superposition and Maximum power transfer theorems.
3. To determine self- inductance of a coil by Anderson's bridge.
4. To determine an unknown Low Resistance using Potentiometer.
5. To compare capacitances using De'Sauty's bridge.
6. Determination of constants of a ballistic galvanometer.
7. Determination of figure of merit of a moving coil galvanometer.

Semester III
Heat and Thermodynamics (3 Credits)
Paper- PHY-MJ-301T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Ideal gas: Review of the kinetic model of an ideal gas; interpretation of temperature. Equipartition ofenergy; Specific heats of gases,

Real gas: Van der Waals model; equation of state, critical constants. **Transport Phenomena:** Mean free path, transport of momentum (viscosity), of energy (thermal conduction) and matter (diffusion).

Joule-Thomson and adiabatic cooling: Joule-Thomson expansion; Joule expansion of an ideal gas; cooling in J-T expansion, adiabatic expansion of an ideal gas, principles of regenerative and cascade cooling, liquefaction of gases.

The laws of thermodynamics: Carnot engine and its efficiency, Carnot's theorem, the second law of thermodynamics. Entropy as a thermodynamic variable; reversible and irreversible processes. Principle of increase of entropy. Thermodynamic scale of temperature; its identity with perfect gas scale, impossibility of attaining the absolute zero (third law).

Thermodynamic relationships: Maxwell's equations; application to Clausius-Clapeyron equation and Joule-Thomson effect. Thermodynamic potentials: Relation to thermodynamic variables;

Black body radiation: Stefan-Boltzmann law, Wien's displacement law. Rayleigh-Jeans law, Planck's hypothesis, mean energy of an oscillator and Planck's law

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988,.

PHYSICS LAB- PHY-MJ-301P (1 Credit) FM: 25

1. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
2. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee's disc method.
3. To determine the Temperature Coefficient of Resistance by Platinum ResistanceThermometer (PRT).
4. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature ofits Two Junctions.
5. To calibrate a thermocouple to measure temperature in a specified Range using (1) NullMethod and to determine Neutral Temperature.
6. Determination of Stefan's constant.
7. Verification of Planks radiation formulae.

Semester III
Wave and Oscillations (3 Credits)
Paper- PHY-MJ-302T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Even and odd functions and their Fourier expansions. Application. Analysis of saw-tooth and square wave.

Oscillations: 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;

Wave Motion and Velocity: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities, Group and Phase velocities, Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave, Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.

Ultrasonics: Classification of Sound waves, Ultrasonics, Quartz crystal and Piezo electric effect, Magnetostriction effect, Properties of Ultrasonic, Detection of ultrasonic waves, Determination of velocity of ultrasonic waves in liquid (Acoustic grating method). Application of Ultrasonics.

Acoustics: The acoustics of halls, Reverberation period, Sabine's formula. Acoustic defects in a halland their correction.

Reference Books

1. Waves and Acoustics, P. K. Chakraborty and Satyabrata Chowdhury.
2. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
3. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
4. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

PHYSICS LAB- PHY-MJ-302P (1 Credit) FM: 25

1. Verification of laws of transverse vibration in a string using sonometer.
2. Determination of speed of sound using Kundt's tube.
3. To determine the frequency of electrically maintained tuning fork by Melde's experiment.
4. To determine the Density of material of wire using sonometer.
5. To determine the Velocity of sound by resonance column.

Semester IV
Optics (3 Credits)
Paper- PHY-MJ-401T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Wave Optics: Electromagnetic nature of light, Definition and properties of wave front, Huygens Principle.

Interference: Division of amplitude and wavefront, Young's double slit experiment, Fresnel's Biprism, Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films, Fringes of equal inclination; Fringes of equal thickness, Newton's Rings: Measurement of wavelength and refractive index.

Interferometer: Michelson Interferometer, Idea of formation of fringes, Determination of Wavelength, Wavelength Difference. Fabry-Perot interferometer – theory and applications.

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

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 diffraction pattern of a straight edge, a slit and a wire.

Polarization: Description of Linear, Circular and Elliptical Polarization. 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.

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Calculation of angle of rotation. Specific rotation. Laurent's half-shade polarimeter.

Reference Books

1. Introduction to Geometrical and Physical Optics, B. K. Mathur.
2. Geometrical and Physical Optics, P. K. Chakraborty.
3. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
4. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
5. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

PHYSICS LAB- PHY-MJ-401P (1 credit) FM: 25

1. Familiarization with: Schuster`s focusing; determination of angle of prism.
2. To determine refractive index of the Material of a prism using sodium source.
3. To determine the dispersive power and Cauchy constants of the material of a prism usingmercury source.
4. To determine wavelength of sodium light using Fresnel Biprism.
5. To determine wavelength of sodium light using Newton's Rings.
6. To determine the thickness of a thin paper by measuring the width of the interferencefringes produced by a wedge-shaped Film.
7. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using planediffraction grating.
8. To determine dispersive power and resolving power of a plane diffraction grating.

Semester IV
Electrostatics and Magnetism (3 Credits)
Paper- PHY-MJ-402T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

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.

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson Equations and their solutions. The Uniqueness Theorem. Potential and Electric Field due to a dipole. Force and Torque on a dipole. Electrostatic energy of system of charges. Conductors in an electrostatic Field. Surface charge and force on a conductor. Parallel-plate capacitor. Capacitance of an isolated spherical conductor.

Separation of variable: rectangular Cartesian coordinate, spherical coordinate

Method of images: point charge close to a grounded conducting plane, point charge near a grounded Conducting sphere.

Multipole expansion; Multipole expansion of the electrostatic potential, monopole, dipole, quadrupole Approximations at large distances,

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss' Law in dielectrics. Claussius-Mossotti equation, Langevin- Debye equation.

Magnetic Properties of Matter: Magnetization vector **(M).** Magnetic Intensity **(H).** Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism. B-H curve and hysteresis. Boundary conditions at the interface of two media and application to a sphere of magnetic material placed in a uniform magnetic induction, Dia-magnetizing factor. Origin of magnetic moment. Langevin's Theory of Diamagnetism and Paramagnetism.

Reference Books:

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

PHYSICS LAB- PHY-MJ-402P (1 credit) FM: 25

1. Measurement of field strength B and its variation in a solenoid
2. Measurement of susceptibility of paramagnetic solution (Quink's Tube Method)
3. To measure the Magnetic susceptibility of Solids.
4. Verification of Curie-Weiss Law for a ferroelectric material.
5. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.

Semester IV
Mathematical Physics- II (3 Credits)
Paper- PHY-MJ-403T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Frobenius Method and Special Functions: Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Confluent Hypergeometric 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.

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string.

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

Reference Books:

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

PHYSICS LAB- PHY-MJ-403P (1 credit) FM: 25

Topics	Description with Applications
Introduction to Numerical computation software Scilab	Introduction to Scilab, Advantages & disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initializing variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting, Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization. User defined functions, Introduction to Scilab functions, variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions,
	Numerical methods and developing the skills of writing a program.
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohms law to calculate R, Hooke's law to calculate spring constant
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)
Solution of ODE First order Differential equation Euler, modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method	First order differential equation, Radioactive decay, Current in RC, LC circuits with DC source, Newton's law of cooling, Classical equations of motion, Second order Differential Equation, Harmonic oscillator (no friction), Damped Harmonic oscillator, Over damped, Critical damped, Oscillatory, Forced Harmonic oscillator, Transient and, Steady state solution Apply above to LCR circuits also.

Semester V
Analog Electronics (3 Credits)
Paper- PHY-MJ-501T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Semiconductor Physics : Semiconductor, Conduction in semiconductors, Energy bands and conduction, conductivity, mobility and resistivity, Doping, Diffusion, p-n junction, biasing, depletion layer capacitance, Diode equation, Zener diode.

Diode and wave shaping circuits: Diode as a circuit element, Diode parameters, Temperature effects,Diode model, Diode as a switch, Diode switching parameters, effects, Diode model, Diode rectifier circuits(half and full wave), Ripple factor, Smoothing RC filters, Limitation of diode as a rectifier, Clipping and clamping circuits. Zener diode, characteristics and Zener diode regulated power supply.

BJT-based circuits: Bipolar junction transistor structure, modes of operation, dc characteristics and dc parameters, Load line and Q-point, stabilization, Small -singal equivalent models (low and high frequencies).

FET-based circuits: Junction field -effect transistor structure, modes of operation, dc characteristics and dc parameters, Load line and Q-point, Biasing circuits (voltage divider and self bias) and Q-point stabilisation, Small -signal equivalent models (low and high frequencies).

Ampilifiers: Features of amplifier configurations, Analysis and design of RC coupled voltage amplifier using BJT (CE mode) and JFET (Cs mode), Frequency response, Concept of Bode plots, Classes of amplifiers, Push-pull class A and class B-amplifier.

Feedback and oscillation: Feedback concept and feedback equation, Positive and negative feedback, Characteristics of negative feedback, Criteria of oscillations, RC phase shift oscillator, RF oscillators (Hartley and Colpitt), Astable multivibrator using BJT.

Reference Books:

1. Foundations of Electronics- Raskhit and Chattopadhyay
2. Concept of Electronics- D. C. Tayal (Himalaya Publication)
3. Electronic devices and circuits R. L. Boylstad (Pearson India)
4. Electronic Principles- A. P. Malvino (Tata McGraw Hill)
5. Principles of Electronics- V. K. Mehta and Rohit Mehta (S. Chand Publication)
6. OP-Amps and Linear Integrated Circuit-R. A. Gayakwad (Prentice Hall)
7. Physics of Semiconductor devices, Donald A Neamen (Prentice Hall)

PHYSICS LAB- PHY-MJ-501P (1 credit) FM: 25

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
7. To design a phase shift oscillator of given specifications using BJT.

Semester V
Electromagnetic Theory (3 Credits)
Paper- PHY-MJ-502T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Maxwell Equations: Review of Maxwell's equations. Displacement Current. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting vector and Poynting Theorem. Electromagnetic (EM) Energy Density.

EM Wave Propagation in dielectric Media: Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, 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.

EM Wave in conducting Media: Propagation through conducting media, relaxation time, skin depth. reflection at and transmission through a conducting surface Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth. Electromagnetic theory of dispersion.

Electromagnetic potentials: Magnetic vector potential **A** and scalar potential φ. Lorentz gauge, Coulomb'sgauge. Maxwell's equation in terms of potentials. Gauge invariance,

Radiation from accelerated charge: Retarded potential, Lenard- Weichart potential, electric dipole radiation, magnetic dipole radiation, Radiation from an accelerated charged particle along and perpendicular to the direction of motion.

Reference Books:

1. Electromagnetic Theory, Chopra and Agarwal.
2. Electromagnetics, B. B. Laud.
3. Electromagnetic Theory, Satya Prakash
4. Electromagnetic Theory, Gupta and Kumar
5. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
6. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning

PHYSICS LAB- PHY-MJ-502P (1 credit) FM: 25

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
5. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
6. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Semester V
Classical Mechanics (3 Credits)
Paper- PHY-MJ-503T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Constrained Motion: Constraints- Definition, Classification and Examples, Degrees of Freedom and Configuration space, Constrained system, Forces of constraint and Constrained motion, Generalised coordinates, Transformation equations and Generalised notations & relations, Principle of Virtual work and D'Alembert's principle.

Lagrangian Formalism: Lagrangian for conservative & non-conservative systems, Lagrange's equation of motion, Comparison of Newtonian and Lagrangian formulations, Applications to simple systems such as coupled oscillators, Cyclic coordinates, symmetries and conservation laws.

Hamiltonian Formalism: Canonical momenta & Hamiltonian, Hamilton's equations of motion, Principle of least action, Applications: Hamiltonian for a harmonic oscillator, compound pendulum, Canonical transformation, Poisson Brackets, Hamilton-Jacobi theory, solution of harmonic oscillator using Hamilton-Jacobi theory.

Motion under Central force: Kepler's laws, center of mass and lab frame of reference, Differential equation for the orbit, Condition for stable circular orbit, Rutherford scattering.

Rigid body dynamics: moment of inertia and product of inertia, rotating top, precession and nutation, Euler angles.

Rotating frame of reference: rotating frame of reference, centrifugal force, Coriolis force and its effects.

Reference Books:

1. Herbert Goldstein, Charles P. Poole, John L. Safko, "Classical Mechanics", Pearson Education, India, 2011, 3e
2. J. C. Upadhyaya, "Classical Mechanics", Himalaya Publishing House, India, 2014.
3. N.C. Rana, P.S. Joag, "Classical Mechanics", McGraw Hill, 2017
4. Intoduction to Classical mechanics, Nikhil Ranjan Roy, 2016, Vikash Pub House Pvt. Ltd.
5. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
6. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
7. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
8. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.

PHYSICS LAB- PHY-MJ-503P (1 credit) FM: 25

1. To determine the acceleration due to gravity by object drop method.
2. To determine the radius of gyration and moment of inertia of a Compound Pendulum about its centre of gravity.
3. Determination of the moment of inertia of given body using inertia table.
4. Determination of the moment of inertia of given body using inertia table using lamp and scale arrangement.
5. Prove the perpendicular axis theorem of moment of inertia using inertia table.
6. Study two normal modes of Coupled Oscillator and record the oscillations to determine the time period for both the modes.
7. Record the oscillations for Resonance Mode. To determine the Coupled Time Period and Beat Time Period of the oscillation also compare the experimental values of time period with calculated values?
8. To determine the Spring Constant with the help of Coupled Oscillator.

Semester VI
Relativity (3 Credits)
Paper- PHY-MJ-601T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Review Newtonian mechanics: Galilean relativity, Newtonian mechanics, Electrodynamics and inconsistency with Galilean relativity, Michelson-Morley experiment - ether and experiments for its detection, failure to detect ether. Measurement of velocity of light in moving frames. Lorentz, Poincare and developments towards relativity

Einstein's special theory: Constancy of velocity of light as a postulate. Derivation of Lorentz transformation. Length contraction and time dilation. Simultaneity, synchronization and time dilation, Einstein's velocity addition rule Variation of mass with velocity, mass-energy equivalence, relativistic formulae for momentum and energy, relativistic Doppler Effect.

The structure of space-time: Four-vectors; invariance of an interval, time-like, space-like and light-like intervals, Minkowski world.

Relativistic electrodynamics: Electric field of a point charge in uniform motion; transverse components, magnetism as a relativistic phenomenon. Invariance of Maxwell's equations, Four-dimensional vector potential, Energy-Momentum Tensor and Conservation Laws.

Reference Books:

1. Introduction to Special Theory of Relativity by Resnick
2. Relativity by A. Einstein
3. Classical Electrodynamics by J.D. Jackson
4. Electrodynamics by W. K. H. Panofsky & M. Phillips
5. Classical Mechanics by H. Goldstein

PHYSICS LAB- PHY-MJ-601P (1 credit) FM: 25

1. Measurement of Planck's constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the acceleration due to gravity by Simple Pendulum
5. To determine the acceleration due to gravity with the help of Compound Pendulum

Semester VI
Digital Electronics (3 Credits)
Paper- PHY-MJ-602T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

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. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.
Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Min terms and Max terms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method (SOPs), (2) Product of Sums (POSs) and (3) Karnaugh Map.
Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.
Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders, 4-bit binary Adder.
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.
Timers: IC 555: block diagram and applications: Astable multivibrator and Mono-stable multivibrator.
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).
Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

Reference Books:

1. Digital Principles and Applications, A.P. Malvino, D. P. Leach and Saha, 7th Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Systems: Principles & Applications, R. J. Tocci, N. S. Widmer, 2001, PHI Learning
5. Logic circuit design, Shimon P. Vingron, 2012, Springer.
6. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
7. Digital Electronics, Floyd.
8. Digital Computer Electronics, Malvino

PHYSICS LAB- PHY-MJ-602P (1 credit) FM: 25

1. To design a switch (NOT gate) using a transistor.
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To design a combinational logic system for a specified Truth Table.
4. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
5. To minimize a given logic circuit.
6. Half Adder, Full Adder and 4-bit binary Adder.
7. Half Adder and Full Adder Truth table verification using I.C.
8. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
9. To design an astable multivibrator of given specifications using 555 Timer.
10. To design a monostable multivibrator of given specifications using 555 Timer.

Semester VI
Basic Quantum Mechanics (3 Credits)
Paper- PHY-MJ-603T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Origin of Quantum theory, Inadequacy of classical mechanics, Wave – particle duality of matter and radiation (Photoelectric effect, Compton effect, Davisson and Germer experiment etc), Stern and Gerlach Experiment, Franck and Hertz experiment, Postulates of Quantum Mechanics, Inadequacy of Quantum Theory.

Wave Mechanical Concepts: Matter waves, Principle of superposition, Time dependent and independent Schrodinger Equations, Interpretation of the Wave function (Probability density, expectation value etc.), Ehrenfest's Theorem, Concept of stationary states.

General formalism of Quantum Mechanics: Linear vector space, Hilbert space, operators and associated algebra, Hermitian operators (Theorems), Unitary and projection operators commuting and noncommuting operators, simultaneous eigenfunctions, orthogonal functions, Eigenvalues and eigenfunction.

General uncertainty principle: Simultaneous measurability of observables, compatible observables and commutating operators, Complete set of commuting operators, Derivation of general uncertainity relation and simple applications Heisenberg's Uncertainty Principle.

Dirac Notation: Concept of kets and bras, scalar product, bra and ket algebra, Orthonormality relation, condition for Hermicity of operator

Heisenberg Matrix Mechanics: Matrix representation of wave function and operators, Schrodinger Equation in matrix form, eigenvalue problems, Linear Harmonic oscillator

Equation of motion: Schrodinger picture, Heisenberg picture and interaction picture, Equation of motion in momentum representation, application to Linear Harmonic Oscillator.

Reference Books:

1. Introduction to Quantum mechanics, Nikhil Ranjan Roy, 2016, Vikash Publishing House Pvt.Ltd.
2. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGrawHill
3. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edition, 2002, Wiley.
4. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
5. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
6. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
7. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer

PHYSICS LAB- PHY-MJ-603P (1 credit) FM: 25

Use 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 thehydrogen atom:

$d^2y/dr^2 = A(r)u(r)$, $A(r) = 2m/h^2 \times [V(r) - E]$ 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 $e = 3.795\ (eVÅ)^{1/2}$, $ħc = 1973$ (eVÅ) and $m = 0.511 \times 10^6\ eV/c^2$.

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

$d^2y/dr^2 = A(r)u(r)$, $A(r) = 2m/h^2 * [V(r) - E]$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential $V(r) = -e^2/r \times (e^{-r/a})$

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 $e = 3.795\ (eVÅ)^{1/2}$, $m = 0.511 \times 10^6$ eV/c^2, and a
= 3 Å, 5 Å, 7 Å. In these units $ħc = 1973$ (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

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

mass m:$d^2y/dr^2 = A(r)u(r)$, $A(r) = 2m/h^2 \times [V(r) - E]$

For the anharmonic oscillator potential $V(r) = ½\ kr^2 + 1/3br^3$ for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose $m = 940\ MeV/c^2$, $k = 100\ MeV\ fm^{-2}$, $b = 0, 10, 30\ MeV\ fm^{-3}$. In these units, cħ
= 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for allthree cases.

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

molecule:$d^2y/dr^2 = A(r)u(r)$, $A(r) = 2μ/h^2 \times [V(r) - E]$
Where μ is the reduced mass of the two-atom system for the Morse potential
$(r) = D\ (e^{-2αr'} - e^{-αr'})$, $r' = (r-r_0)/r$
Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significantdigits. Also plot the corresponding wave function.
Take: $m = 940 \times 106\ eV/C^2$, $D = 0.755501$ eV, $α = 1.44$, $r_o = 0.131349$ Å.

Semester VI
Material Characterization Techniques (3 Credits)
Paper- PHY-MJ-604T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

X-Ray Diffraction: X-ray diffraction. Diffraction under non-ideal conditions. Atomic scattering and Geometrical structure factors. Factors influencing the intensities of diffracted beams. Powder X-ray diffractometer. Applications of XRD in ceramic materials.

Microscopy: Study of the morphology, aggregation, size and microstructure of ceramic materials using. Optical microscope, quantitative phase analysis. Principle of electron microscopy. Construction and operation of Transmission Electron Microscope and Scanning Electron Microscope. Electron diffraction by crystalline solids; selected area diffraction. Atomic Force Microscope. Mechanism of image formation in SEM and its processing. Electron microprobe analysis (EDAX and WDS). Preparation of samples for electron microscopic studies. ESCA and PES.

Spectroscopy: Spectrophotometric analysis of materials: Basic laws of spectrophotometry and its application in micro analysis in UV/ Visible range, effect of reflectance factor on optical analysis, construction and working principle of spectrophotometer, importance of additive absorbances in multiple analysis of materials. Infrared spectrophotometry: General aspects of IR spectroscopy and its application in structural analysis of systems, sources of IR radiations, Optical systems and operation of FTIR spectrophotometers. Samples preparation, IR analysis and structural co-relations. Fluorescence and Phosphorescence spectroscopy: Basic principle, geometrical optics, construction, working principle and use of fluorescence spectrometers in materials analysis. XRF and on-line analysis of ceramic materials. Electron Spin Resonance spectroscopy in ceramic systems.

Thermal Analysis: DTA, TGA and DSC with suitable examples of glass and ceramic materials.

Reference:

1. Sam Zhang, Lin Li and Ashok Kumar, Materials Characterization Techniques, CRC Press, (2008).
2. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods.
3. Elton N. Kaufmann, Characterization of Materials, Vol.1, Wiley & Sons (2003).
4. R.A. Laudise, Growth of Single Crystals, Prentice Hall, (1973).
5. G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley (Eds.), Springer Handbook of Crystal Growth
6. A. Kumar, Introduction to Solid State Physics, PHI learning private limited, New Delhi.

PHYSICS LAB- PHY-MJ-604P (1 credit) FM: 25

1. Phase identification of an unknown sample by X-ray diffraction spectroscopy. Determination of Miller indices, space group, lattice parameters and unit cell volume of an unknown sample.
2. To carry out plot analysis of X-ray diffraction data to estimate the strain & grain size for given samples.
3. To carry out X-ray diffraction measurements on single crystalline substrate.
4. To determine of Lattice parameters, particles sizes etc. of different powder samples of bulk- /nano-systems (ferrite, α-Fe2O3, γ-Fe2O3) using X-ray diffractograms.
5. To determine the particle size and lattice strain of an unknown powder specimen using Origin software and Scherrer equation.
6. To study the porosity and grain size of thin film and powder samples by Scanning Electron Microscopy.

Semester VII
Atomic and Molecular Physics (3 Credits)
Paper- PHY-MJ-701T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Atomic Physics

Bohr's theory of Hydrogen atom, Bohr- Somerfield theory, Quantum states of an electron in an atom, Vector-atom model, Stern-Gerlach experiment, Spin-orbit coupling, fine structure, relativistic correction, spectroscopic terms and selection rules, hyperfine structure. Exchange symmetry of wave functions. Pauli's exclusion principle, periodic table and alkali atom spectra, LS & JJ coupling, normal and anomalous Zeeman effect, Paschen–Back and Stark effects, X-Rays and Auger transitions, line broadening mechanism.

Molecular Physics

Diatomic molecule as linear symmetric, asymmetric top and spherical top, Rotational spectra of diatomic molecules, rigid rotator and non-rigid rotator, vibrational spectra of diatomic molecules- Harmonic Oscillator, effect of anharmonicity, diatomic molecule as a vibrating rotator, electronic spectra of diatomic molecules, Frank -Condon principle. Raman spectra, rotational and vibrational Raman spectra of diatomic molecules.

Reference Books:

1. **H.E.White** , *Introduction to Atomic spectra*
2. **C.B. Banwell ,** *Fundamental of molecular spectroscopy*
3. **Walker & Straughen,** *Spectroscopy Vol -I ,II, & III*
4. **Herzberg,** *Spectra of diatomic molecules*
5. **J.M. Brown,** *Molecular spectroscopy*

PHYSICS LAB- PHY-MJ-701P (1 credit) FM: 25

1. To determine the first excitation energy of Argon.
2. To determine the Planck's constant using LEDs of at least 4 different colours.
3. To show the tunnelling effect in tunnel diode using I-V characteristics.
4. To determine the wavelength of laser source using diffraction of single slit.
5. To determine the wavelength of laser source using diffraction of double slits.
6. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.

Semester VII
Solid State Physics (3 Credits)
Paper- PHY-MJ-702T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Crystal geometry: Crystal lattice; crystal planes and Miller indices, unit cells. Typical crystal structures; Symmetry elements; rotation, inversion and reflection, point groups and crystal classes.

Crystallography: Diffraction of X-rays by a crystal lattice. Laue's formulation of X-ray diffraction; reciprocallattice, Bragg's equation, Laue spots.

Types of binding in solids (Qualitative idea only): Covalent binding and its origin, Ionic binding, energy of binding, transition between covalent and ionic binding, metallic binding, Van der Waals binding, hydrogen bond.

Lattice Vibrations: Dynamics of a chain of atoms, chain of two types of atoms, optical and acoustic modes,interaction of light with ionic crystals, Einstein's and Debye's theories of specific heats of solids.

Conduction in metals: Drude's theory, Electrical conductivity, Hall-effect and magnetoresistance, thermalconductivity of metals, thermal properties of free-electron gas, Sommerfeld's theory of conduction in metals.

Elementary band theory: Periodic potential and Bloch theorem, Kroning- Penny model, band gap, Effective mass, Band structure of metals, insulators and semiconductors. Conductivity of Semiconductor, mobility.

Superconductivity: Occurrence, Critical temperature and critical magnetic field, Meissner effect, Superconductivity- Type I, Type II.

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
6. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India

PHYSICS LAB- PHY-MJ-702P (1 credit) FM: 25

1. To determine the Hall coefficient of a semiconductor sample.
2. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150^{0}C) and to determine its band gap.
3. To measure the Dielectric Constant of a dielectric Materials with frequency.
4. To determine the refractive index of a dielectric layer using SPR.
5. To determine the value of e/m by using a Bar magnet.

Semester VII
Statistical Mechanics (3 Credits)
Paper- PHY-MJ-703T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy

Classical Theory of Radiation: Properties of Thermal Radiation. Blackbody Radiation. Kirchhoff's law. Stefan-Boltzmann law:. Wien's Displacement law. Wien's Distribution Law. Rayleigh-Jean's Law.

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a Degenerate Bose Gas, Bose Einstein condensation, properties of liquid Helium .

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals,

Reference Books:

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L.Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

PHYSICS LAB- PHY-MJ-703P (1 credit) FM: 25

Use C/C++/Scilab for solving the problems based on Statistical Mechanics like

1. Plot Planck's law for Black Body radiation and compare it with Wein's Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
2. 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
3. Plot Maxwell-Boltzmann distribution function versus temperature.
4. Plot Fermi-Dirac distribution function versus temperature.
5. Plot Bose-Einstein distribution function versus temperature.

Semester VII
Advanced Quantum Mechanics (3 Credits)
Paper- PHY-MJ-704T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

One Dimensional Schrodinger Equation: Free Particle, Potential Step, Potential Barrier and Well, tunneling Effect, Infinite Square Well Potential (Asymmetric and Symmetric), Finite square well potential, Scattering and bound state solutions), Harmonic oscillator

Three-dimensional Schrödinger Equation: Separation of variables in Cartesian & spherical polar coordinates, Free Particle, Particle in box, hydrogen atom, Generalization to 3-D harmonic oscillator and isotropic oscillator, Degeneracy. Free Particle in Spherical Coordinates, Spherical Square Well Potential, Isotropic Harmonic Oscillator, Hydrogen Atom, Effect of Magnetic Fields on Central Potentials

Angular momentum and commutation algebra: Expression for L^2, L_z, L_y & L_x, Eigenvalue and Eigen function, spherical harmonics, commutation relation, Angular momentum and rotation. Commutation relations for angular momentum operators - J^2 & J, Ladder Operator $\mathbf{J}_+$ & $\mathbf{J}_-$, eigen valve and eigen vector, Addition of angular momentum and Clebsch-Gordan Coefficient, Pauli Spin matrices and spin eigen-vectors.

Symmetry in Quantum Mechanics: Symmetry operations and unitary transformations, conservation principles, space and time translations, rotation, space inversion and time reversal, symmetry and degeneracy.

Approximate methods: Variational methods and application to LHO and helium atom, JWKB method, 1-D Bound state system, application to tunneling.

Perturbation theory :

a. **Time-independent perturbation theory:** Non-degenerate perturbation theory, degenerate case, Stark effect, Zeeman effect and other examples,
b. **Time-dependent perturbation theory:** Time-dependent perturbation theory, transition probability calculations, golden rule, adiabatic approximation, sudden approximation.

Reference Books:

1. A Text book of Quantum Mechanics, P.M.Mathews & K.Venkatesan, 2nd Ed., 2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2ndEdn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rdEdn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldhas, 2ndEdn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

PHYSICS LAB- PHY-MJ-704P (1 credit) FM: 25

1. Study of Electron spin resonance- determine magnetic field as a function of the resonancefrequency.
2. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
3. To show the tunneling effect in tunnel diode using I-V characteristics.
4. Quantum efficiency of CCDs
5. Verification of plank's uncertainly principle
6. Determination of wavelength of an electron in ground state of hydrogen and establish de-Broglie relation.

Semester VIII
Nuclear and Particle Physics (3 Credits)
Paper- PHY-MJ-801T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Structure on nucleus: Discovery of the nucleus, composition. Basic properties; charge, mass, size, spin,magnetic moment, electric quadrupole moment, binding energy, binding energy per necleon and itsobserved variation with mass number of the nucleus, semi empirical mass formulae, explanation of thebinding energy curve. Liquid drop model of the nucleus.

Nuclear forces: two-nucleon system, deuteron problem, binding energy, nuclear potential well, pp and pn scattering experiments, meson theory of nuclear forces, e.g. Bartlett, Heisenberg, Majorana forces and potentials, mirror nuclei, nuclear energy levels, nuclear gamma rays.

Radioactivity: decay constant, half-life, mean life; Geiger-Nuttal law, Successive disintegration, secular and transient equilibrium, neutrino and antineutrino, basics of α-decay processes, theory of α- emission, Gamow factor

Detectors for charged particles; Ion chamber, Geiger-Muller counter, resolving time, Scintillation counter.

Accelerators: Need for accelerators; cyclotron, synchrocyclotron, variable energy cyclotron, phasestability.

Nuclear reactions; Rutherford's experiments of nuclear transmutation, conservation theorems, Q-value,threshold energy, cross-section of nuclear reactions. Concept of compound and direct Reaction, resonance reaction,

Artificial radioactivity: Nuclear fission, Neutron reactions, Fermi and transuranic elements, chain reaction, criticality, moderators.

Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Concept of quark model.

Reference Books:

1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
4. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
5. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
6. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi

PHYSICS LAB- PHY-MJ-801P (1 credit) FM: 25

1. Demonstration of presence of Static Electricity
2. Demonstration of phenomenon of Corona Discharge
3. To determine the plateau and optimal operating voltage of a Geiger-Müller
4. To determining the resolving (dead) time τ of a Geiger – Muller counter
5. Determining the efficiency of a Geiger-Muller counter
6. Determining the half-life of a radio isotope using Geiger – Mullercounter
7. Experiment with alpha scintillation counter

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Amartanj Mahato 13.07.23

Semester VIII
Modern Optics (3 Credits)
Paper- PHY-AMJ-801T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

LASER: Elementary idea of spontaneous and induced emission. Life time of excited states (metastable states). Threshold condition for laser oscillation. Rate equations in two and three level system. Actual laser systems: He-Ne laser, Ruby laser. Properties and application of laser radiation.

FIBRE OPTICS: Principle of light guidance in optical waveguides, Numerical aperture, fibre types. Electromagnetic analysis of simple optical waveguide: Basic waveguide equation, propagation mode of symmetric step index planar waveguide, TE and TM modes of symmetric step index planar waveguide, mode cut-off condition, mode theory for optical fibre waveguide, scalar wave-equation and modes of fibre, modal analysis for step index fibre. Pulse propagation in non-dispersive and dispersive medium, Pulse broadening and chirping, Group and phase velocity, Intermodal and intra-modal dispersion, Group velocity (material and waveguide) dispersion, Fiber bandwidth.

Holography: Basic Principle of Holography, Construction and reconstruction of Image on hologram and applications of holography.

PHYSICS LAB- PHY-AMJ-801P (1 credit) FM: 25

1. Experiments on Single mode optical fibre.
2. Experiments on multi-mode optical fibre.
3. Lasers: Study of Laser Beam Parameters.
4. Edser and Butler fringes - Thickness of air film.
5. Study on Mach–Zehnder interferometer
6. To determine the divergence of LASER beam
7. To Experimentally Verify the Sampling Theorem.
8. Study on losses in fusion based splices in optical fiber
9. Measuring the end separation, axial misalignment and angular misalignment loss optical fiber.
10. Study on Spectral analysis of optical fiber using optical spectrum analyzer.
11. Study on Nd-YAG LASER.

Semester VIII
NANO SCIENCE & TECHNOLOGY (3 Credits)
Paper- PHY-AMJ-802T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Nanoscale systems: Length, energy, and time scales - Quantum confinement of electrons in semiconductor nanostructures: Quantum confinement in 3D, 2D, 1D and zero dimensional structures -Size effect and properties of nanostructures- Landauer-Buttiker formalism for conduction in confined geometries - Top down and Bottom up approach.

Quantum dots: Excitons and excitonic Bohr radius – difference between nanoparticles and quantum dots - Preparation through colloidal methods - Epitaxial methods- MOCVD and MBE growth of quantumdots - current-voltage characteristics - magneto tunneling measurements - spectroscopy of Quantum Dots: Absorption and emission spectra - photo luminescence spectrum - optical spectroscopy - linear and nonlinear optical spectroscopy.

Synthesis of nanostructure materials: Gas phase condensation – Vacuum deposition -Physical vapor deposition (PVD) - chemical vapor deposition (CVD) – laser ablation Sol-Gel- Ball milling –Electro deposition- electroless deposition – spray pyrolysis – plasma based synthesis process (PSP) - hydrothermal synthesis.

Characterization: Principle and working of Atomic Force Microscopy (AFM) and Scanning tunneling microscopy (STM) - near-field Scanning Optical Microscopy – Principle of Transmission Electron Microscopy (TEM) – applications to nanostructures – nanomechanical characterization – nanoindentation

Nanotechnology applications: Applications of nanoparticles, quantum dots, nanotubes and nanowires for nanodevice fabrication – Single electron transistors, coulomb blockade effects in ultra-small metallic tunnel junctions - nanoparticles based solar cells and quantum dots based white LEDs –CNT based transistors.

Text Books :

1. Hand book of Nanoscience, Engineering and Technology , Kluwer Publishers, 2002
2. "Sol-Gel Science", C.J. Brinker and G.W. Scherrer, Academic Press, Boston (1994).
3. Nanoscale characterization of surfaces & interfaces, N John Dinardo, Weinheim Cambridge:Wiley-VCH,
4. "Nanotechnology" G. Timp. Editor, AIP press, Springer-Verlag, New York, 1999
5. "Nanostructured materials and nanotechnology'', Concise Edition, Editor:-Hari Singh Nalwa;Academic Press

PHYSICS LAB- PHY-AMJ-802P (1 credit) FM: 25

1. Synthesis of at least two different sizes of Nickel Oxide/ Copper Oxide/ Zinc OxideNano Particles Using Sol-Gel Method.
2. Polymer synthesis by suspension method / emulsion method.
3. B-H loop of nanomaterials.
4. Magnetoresistance of thin films and nanocomposite, I-V characteristics and transient response.
5. Particle size determination by X-ray diffraction (XRD) and XRD analysis of the given XRDspectra.
6. Determination of the particle size of the given materials using He-Ne LASER.
7. Selective area electron diffraction: Software based structural analysis based on TEM based experimental data from published literature. (Note: Later experiment may be performed in the lab based on availability of TEM facility).
8. Surface area and pore volume measurements of nanoparticles (a standard sample and a newsample (if available)).
9. Spectroscopic characterization of metallic, semiconducting and insulating nanoparticles.

Semester VIII
Semiconductor devices (3 Credits)
Paper- PHY-AMJ-803T

Mid Semester: 15 **End Semester: 60** **Full Marks: 75**

Transistors

BJT, JFET, MOSFET and MESFET: Structure, working, derivations of the equation for I-V characteristics under different conditions, high frequency limits.

Metal semiconductor junction

Schottky junction, criteria for formation of Ohmic and Schottky junction, current conduction mechanism across Schottky junction, comparison of Schottky junction and pn junction, current-voltage characteristics of Schottky junctions, applications of Schottky junctions in devices.

Microwave Devices

Structure, working and derivations of the equation for I-V characteristics of Tunnel diode, Transfer electron devices (Gunn diode) and Avalanche Transit Time device (Read, IMPATT diodes and parametric device).

Photonic Devices

Radiative and non-radiative transitions, Optical absorption, Bulk and thin film photoconductive device (LDR), Semiconductor Photo detectors: Types of photo detectors: photoconductors and photodiodes, PIN diodes and APDs, Noise in photo detection. Detector characteristics and device performance, phototransistors, Solar cell (open circuit voltage and short circuit current, fill factor), LED (high frequency limit, effect of surface and indirect recombination current, operation of LED), OLED, Diode lasers (conditions for population inversion, in active region, light confinement factor, optical gain and threshold current for lasing, Fabry-Perrot Cavity Length for
lasing and the separation between modes).

References:

1. **M.S. Tyagi,** Introduction to Semiconductor Materials and Devices, J Wiley.
2. **S. M. Sze,** Physics of Semiconductor Devices, Wiley Eastern Limited.
3. **Ben G. Streetman,** Solid State Electronic Devices, Prentice Hall.
4. **S. M. Sze,** Semiconductor Devices; Physics and Technology, John Wiley

PHYSICS LAB- PHY-AMJ-803P (1 credit) FM: 25

1. BJT based voltage amplifier: design and performance study with and without negative feedback. 2)
2. Design and study the performance of an astable multivibrator using BJT/Op-amp.
3. Design and study bi-stable multivibrator using BJT/ Op-amp.
4. Design a CE transistor amplifier and draw its characteristics.
5. FET based voltage amplifier: design and performance study
6. Study of I-V characteristics of LEDs.

II. Syllabus of Research Course

(To be studied by students who have secure 75% and above marks till semester VI and opt for research course in lieu of advance major course)

Semester VIII
Research Methodology (4 Credits)
PHY-RC-801T

Full Marks: 100

Foundations of Research: Meaning, Objectives, Types and approaches of research, process and steps in it; Research proposal and concept, Research Design: meaning, need, concept and different research designs; Literature survey and review, research design process, error in research; Research Modeling: Types of Models, Model building and stages, Data consideration and testing (Sampling, Collection and Analysis), Heuristic and Simulation

Design of Experiments: Objectives, strategies, Factorial experimental design, Designing engineering experiments, basic principles- replication, randomization, blocking, guidelines for design of experiment, Analysis of variance- ANOVA- Basic principle, one way and two way technique, Analysis of Co-variance- ANOCOVA technique

Report writing and Interpretation: Pre- writing considerations; Meaning and technique of interpretation; Different steps in report writing, Formats of report writing, Thesis writing, Formats of publication in Research journals

Computer Application: Introduction to computers, computer arithmetic, Application of MS-office; Data presentation and analysis in MS-Excel, Report writing in MS-word, Seminar presentation by using PPT, Use of tools/techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MSOffice, Use of plagiarism software like Turnitin, Urkund/Ouriginal and other open source software tools; Data base and research metrics: Databases- Indexing databases, Citation databases: Web of Science, Scopus, etc.; Research metrics - Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g index, i10 index.

References Books:

1. Monrgomery, Douglas C, (2007)5/e, Design and Analysis of Experiments (Wiley India)
2. Kothari, C. R. (2004), 2/e, Research Methodology- Methods and Techniques
3. Fisher R.A. (2002), Statistical Methods for Research Workers by Cosmo Publications

Semester VIII
Research Proposal (4 Credits)
PHY-RC-802T

Full Marks: 100

Students are required to write research proposal, review literature and collect data. They will be evaluated on the basis of presentation of their work.

Semester VIII
Research Report (4 Credits)
PHY-RC-803T

Full Marks: 100

Students are required to write a research thesis on the basis of their research proposal, review literature and collect data. They will be evaluated on the basis of thesis submitted of their work.

III. Skill Enhancement Course (SEC) of (2T + 1P) Credits each

Semester	Paper code	Course Title (Credit)
Semester 1	PHY-SEC-101T/ PHY-SEC-101P	Renewable Energy and Energy Harvesting (2T+1P Credits)
Semester 2	PHY-SEC-201T/ PHY-SEC-201P	Python Programming (2T+1P Credits)
Semester 3	PHY-SEC-301T/ PHY-SEC-301P	Numerical Methods (2T+1P Credits)

Semester I

RENEWABLE ENERGY AND ENERGY HARVESTING (2 Credit)

PHY-SEC-101T

FM: 50

Fossil fuels and Alternate Sources of energy: Fossil fuels and Nuclear Energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning.

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

Geothermal Energy: Geothermal Resources, Geothermal Technologies.

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

Reference Books:

1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
2. Solar energy - M P Agarwal - S Chand and Co. Ltd.
3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
4. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford

PHY-SEC-101P (1 Credit) FM: 25

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage using thermoelectric modules.
4. Performance testing of solar cooker.
5. Measurement of I-V characteristics of solar cell.
6. Study the effect of input light intensity on the performance of solar cell.
7. Study the characteristics of wind.
8. Study of charge and discharge characteristics of storage battery.
9. Study of charging and discharging behavior of a capacitor.
10. Performance estimation of a fuel cell.
11. Study of effect of temperature on the performance of fuel cell

Semester II
PYTHON PROGRAMMING (2 Credit)
PHY-SEC-201T

FM: 50

Introduction: Fundamental of computers, components of a computer system: hardware, software. Introduction to operating system, parts of windows, files and folders. Importance of computers in Physics, paradigm for solving physics problems for solution. Algorithm: Definition, properties and development. Flowchart: Concept of low chart, symbols, guidelines, types.

Introduction to Python Programming: Structure of a Python Program, syntax and semantics, Python interpreter/ shell, indentation, executing simple programs in Python. Identifier and keywords, literals, number and strings, operators and expressions, Input and Output statements, control structures (conditional statements, loop control statement, break, continue and pass), errors and exception handling.

User Defined Functions: defining functions, passing arguments and returning values, default arguments

Data Structures: Strings, Lists, Tuples, Sets, Dictionaries, their built-in functions, operators and operations.

Reference Books:

1. Programming and problem solvindwith Python , A N Kamthane and A A Kamthane, TMH.
2. 2. Introduction to Computing and Problem solving using Python, E Balagurusamy, TMH.
3. Python Programming- A modular approach, S. Taneja and N Kumar, Pearson Education.

Python Programming Lab PHY-SEC-201P (1 Credit) FM: 25

1. Exercises on syntax on usage of Python language.
2. Usage of Windows (GUI) commands and applications, familiarity with DOS commands and working in an editor to write sources codes in Python.
3. Generate the Fibonacci series up to the given range N and also print the number of elements in the series.
4. To print out all natural even/ odd numbers between given limits.
5. To find maximum, minimum and range of a given set of numbers.
6. Calculating Euler number using exp(x) series evaluated at x=1
7. Calculate factorial of a given number and in a range.
8. Find all the roots of a quadratic equation for non – zero coefficients A, B and C.
9. Calculate the value of sin (x) and cos (x) using the series. Also print sin (x) and cos (x) value using library function.
10. Generate and print prime numbers up to an integer N.
11. Find the sum & difference of two matrices of order P x Q and R x S.
12. Find the product of two matrices of order P x Q and R x S.

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Semester III
NUMERICAL METHODS (2 Credit)
PHY-SEC-301T

FM: 50

Solution of algebraic and transcendental equations: Bisection method, Regula-Falsi method, Newton-Raphson method.

Solution of simultaneous equations: Gauss's elimination method, Matrix inversion by triangularization method. Calculus of finite difference: The operators Δ, ∇, E, factorial notation, their properties and inter-relation between them, Fundamental theorem of difference calculus, divided differences.

Interpolation: Newton's forward and backward difference interpolation formula, Lagrange's interpolation formula, central difference interpolation, Gauss's forward, backward and central difference interpolation formula.

Numerical differentiation: Derivative using forward, backward and central difference interpolation formulae.

Numerical integration: General quadrature formula, Simpson's one-third and three eighth rule, Weddle's rule, Newton-Cote's method.

Solution of ordinary differential equations: Picard's method of successive approximations,

Note: USE OF SCIENTIFIC CALCULATOR ALLOWED.

Reference Books:

1. Numerical Analysis: J. B. Scarborough.
2. Numerical Analysis: G. S. Mallik.
3. Numerical Analysis: G. Shankar Rao.
4. Numerical Methods: B. S. Grewal.
5. S. S. Shastry, Introductory methods of numerical analysis.

PHY-SEC-301P (1 Credit) FM: 25

1. Program to find the roots of non-linear equation using bisection method.
2. Program to find the roots of non-linear equation using newton's method.
3. curve fitting by least – square approximations.
4. Program to solve the system of linear equations using gauss - elimination method.
5. Program to integrate numerically using simpson's rules.
6. Program to find numerical solution of ordinary differential equations by Runge- kutta method.

IV. Internship

PHY-INT-501P/APP-501P/PRO-501P

Semester V - One paper of 4 credits (Compulsory for all students).

Students are required to undergo an industrial/Professional training/Dissertation/ Project of duration not less than 4 weeks.

V. Physics - Minor Courses (Traditional) of Four (04) credits each

(To be opted by students with Major courses other than Physics)

Semester	Paper code	Course Title (Credit)
Semester 1	PHY-MN101T/ PHY-MN101P	General Physics (3T+1P Credits)
Semester 3	PHY-MN301T/ PHY-MN301P	Electricity and Magnetism (3T+1P Credits)
Semester 5	PHY-MN501T/ PHY-MN501P	Thermal Physics (3T+1P Credits)
Semester 7	PHY-MN701T/ PHY-MN701P	Wave Optics (3T+1P Credits)

Semester I
General Physics (3 Credits)
Paper-PHY-MN-101T

Full Marks: 75

Fundamentals of Dynamics: Reference frames, Inertial frames, Review of Newton's Laws of Motion, Dynamics of a system of particles, Centre of Mass, Principle of conservation of linear momentum, Impulse, Momentum of variable-mass system: motion of rocket.

Rotational Dynamics: Angular momentum of a particle and system of particles, Torque, Principle of conservation of angular momentum, Moment of Inertia, Calculation of moment of inertia for rectangular, cylindrical and spherical bodies, Kinetic energy of rotation, Motion involving both translation and rotation.

Elasticity: Elastic constants and interrelation between them, Twisting torque on a Cylinder or Wire and twisting couple.

Surface Tension: Ripples and Gravity waves, Determination of Surface Tension by Jaeger's and Quinke's methods, Temperature dependence of Surface Tension.

Fluid Motion: Poiseuille's Equation for flow of a Liquid through a Capillary Tube and the corrections.

Central Force Motion: Motion of a particle under a central force field, Two-body problem: its reduction to one-body problem and solution, Kepler's Laws, Weightlessness.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
5. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

D.S. Mathur, P.S. Hemne, "Mechanics", S. Chand Publishing, 1981, 3e

PHYSICS LAB- PHY-MN-101P (1 credit) FM: 25

1. Measurements of length (or diameter) using vernier caliper.
2. Measurements of length (or diameter) using screw gauge.
3. Measurements of length (or diameter) using travelling microscope.
4. To study the random error in observations.
5. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
6. To determine the Moment of Inertia of a Flywheel.
7. To determine the value of g using Bar Pendulum.

Semester III
Electricity and Magnetism (3 Credits)
Paper-PHY-MN-301T

Full Marks: 75

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) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential.Magnetic Force on (1) on point charge (2) on current carrying wire (3) between current elements.

DC circuits: growth and decay of current in CR and LR circuits, Growth and decay of currents in Series LCR circuit.

AC Circuits: AC Circuits: Kirchhoff's 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.

Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Logarithmic damping.

Network theorems: 2-port network and its T and π representations, T and π equivalence, h-parameters representations, Thevenin, Norton, Superposition, Reciprocity and Maximum power transfer theorems.

Reference Books:

1. Electricity, Tayal D. C.
2. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury,
3. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
4. Electricity and Magnetism, Chattopadhyaya and Rakshit
5. Electricity and Magnetism, Mahajan and Rangwala
6. Electricity and Magnetism, K. K. Tewary.

PHYSICS LAB- PHY-MN-301P (1 credit) FM: 25

1. (a) To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer: (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 B and its variation in a Solenoid (Determine dB/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 (b) To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
7. To determine a Low Resistance by Carey Foster's Bridge.
8. To verify the Thevenin and Norton theorems
9. To verify the Superposition, and Maximum Power Transfer Theorems

Semester V
Thermal Physics (3 Credits)
Paper-PHY-MN-501T

Full Marks: 75

Ideal gas: Review of the kinetic model of an ideal gas; interpretation of temperature. Equipartition ofenergy; Specific heats of gases,

Real gas: Van der Waals model; equation of state, critical constants. **Transport Phenomena:** Mean free path, transport of momentum (viscosity), of energy (thermal conduction) and matter (diffusion).

Joule-Thomson and adiabatic cooling: Joule-Thomson expansion; Joule expansion of an ideal gas; cooling in J-T expansion, adiabatic expansion of an ideal gas, principles of regenerative and cascade cooling, liquefaction of gases.

The laws of T hermodynamics: Carnot engine and its efficiency, Carnot's theorem, the second law of thermodynamics. Entropy as a thermodynamic variable; reversible and irreversible processes. Principle of increase of entropy. Thermodynamic scale of temperature; its identity with perfect gas scale, impossibility of attaining the absolute zero (third law).

Black body radiation: Stefan-Boltzmann law, Wien's displacement law. Rayleigh-Jeans law, Planck's hypothesis, mean energy of an oscillator and Planck's law

Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988,.

PHYSICS LAB- PHY-MN-501P (1 credit) FM: 25

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 determine 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 a bad conductor by Lee and Charlton's disc method.
6. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
7. To study the variation of thermo emf across two junctions of a thermocouple with temperature.

Semester VII
Wave Optics (3 Credits)
Paper-PHY-MN-701T

Full Marks: 75

Interference: Division of amplitude and wavefront. Young's double slit experiment. Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination; Fringes of equal thickness. Newton's Rings: Measurement of wavelength and refractive index.

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

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 ZonePlate, Fresnel diffraction pattern of a straight edge, a slit and a wire.

Polarization: Description of Linear, Circular and Elliptical Polarization. Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Phase Retardation Plates: Quarter-Wave and Half- Wave Plates.

Reference Books

1. Introduction to Geometrical and Physical Optics, B. K. Mathur.
2. Geometrical and Physical Optics, P. K. Chakraborty.
3. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
4. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
5. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

PHYSICS LAB- PHY-MN-701P (1 credit) FM: 25

1. Familiarization with Schuster`s focusing; determination of angle of prism.
2. To determine the Refractive Index of the Material of a Prism using Sodium Light.
3. To determine Dispersive Power of the Material of a Prism using Mercury Light.
4. To determine the value of Cauchy Constants.
5. To determine the Resolving Power of a Prism.
6. To determine wavelength of sodium light using Fresnel Biprism.
7. To determine wavelength of sodium light using Newton's Rings.
8. To determine the wavelength of Laser light using Diffraction of Single Slit

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VI. Minor Courses (Vocational) of Four (04) Credits each
(To be opted by students with Major courses other than Physics)

Semester	Paper code	Course Title (Credit)
Semester 2	PHY-MVC-201T/ PHY-MVC-201P	Energy Sources (3T+1P Credits)
Semester 4	PHY-MVC-401T/ PHY-MVC-401P	Basic Instrumentation (3T+1P Credits)
Semester 6	PHY-MVC-601T/ PHY-MVC-601P	Optical Instruments (3T+1P Credits)
Semester 8	PHY-MVC-801T/ PHY-MVC-801P	Digital Systems (3T+1P Credits)

Semester II
Energy Sources (3 Credits)
PHY-MVC-201T

Full Marks: 75

Non-Renewable energy sources : Introduction: Energy concept-sources in general, its significance & necessity, Classification of energy sources: Primary and Secondary energy, Commercial and Non-commercial energy, Renewable and Non-renewable energy, Conventional and Non-conventional energy, Based on Origin-Examples and limitations. Importance of Non-commercial energy resources.

Conventional energy sources: Fossil fuels & Nuclear energy- production & extraction, usage rate and limitations. Impact on environment and their issues & challenges. Overview of Indian & world energy scenario with latest statistics- consumption & necessity. Need of eco-friendly & green energy & their related technology.

Renewable energy sources: Introduction: Need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

Solar energy: Solar Energy-Key features, its importance, Merits & demerits of solar energy, Applications of solar energy. Solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell -brief discussion of each. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

Wind and Tidal Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies, Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices, Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy.

Geothermal and hydro energy: Geothermal Resources, Geothermal Technologies, Hydropower resources, hydropower technologies, environmental impact of hydro power sources, Carbon captured technologies, cell, batteries, power consumption

Reference Books:

1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
2. Solar energy - M P Agarwal - S Chand and Co. Ltd.
3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
4. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford

PHYSICS LAB- PHY-MVC-201P (1 credit) FM: 25

1. Performance testing of solar cooker.
2. Measurement of I-V characteristics of solar cell.
3. Study the effect of input light intensity on the performance of solar cell.
4. Study the characteristics of wind.
5. Study of charge and discharge characteristics of storage battery.
6. Study of charging and discharging behavior of a capacitor.
7. Performance estimation of a fuel cell.
8. Study of effect of temperature on the performance of fuel cell

Semester IV

Basic Instrumentation (3 Credits)
PHY- MVC-401T

Full Marks: 75

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.

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.

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

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

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

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.

Reference Books:

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

PHYSICS LAB- PHY- MVC-401P (1 credit) FM: 25

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage & current.
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.
6. Measurement of rise, fall and delay times using a CRO.

Semester VI
Optical Instruments (3 Credits)
PHY- MVC-601T

Full Marks: 75

Basics of Optics: Scope of optics, optical path, laws of reflection and refraction as per Fermat's principle, magnifying glass, Lenses (thick and thin), convex and concave lenses, Lens makers formulae for double concave and convex lenses, lens equation. Focal and nodal points, focal length, image formation, combination of lenses, dispersion of light: Newton's experiment, angular dispersion and dispersion power. Dispersion without deviation. (No derivations; concepts to be discussed qualitatively).

Camera and microscopes:

Human eye (constitution and working),

Photographic camera (principle, construction and working), construction, working and utilities of

(i) Simple microscopes
(ii) Compound microscope
(iii) Electron microscopes
(iv) Binocular microscopes

Telescopes and Spectrometer:

Construction, working and utilities of
(i) Astronomical telescopes
(ii) Terrestrial telescopes
(iii) Reflecting telescopes,

Spectrometer – Construction, working and utilities, measurement of refractive index.

Reference Books

1. Galen Duree. Optics for Dummies. Wiley. 2011.
2. Blaker J W. Optics: An Introduction for Students of Engineering. Pearson, 2015.
3. Hecht E. Optics. Pearson. 5th Edition, 2019.
4. Khurana A K. Theory and Practice of Optics & Refraction. Elsevier India. 2016.

PHYSICS LAB- PHY- MVC-601P (1 credit) FM: 25

1. Find position and size of the image in a magnifying glass and magnification.
2. Observe rain bows and understand optics. Create a rainbow.
3. Find out what makes a camera to be of good quality.
4. Observe the dispersion of light through prism.
5. Make a simple telescope using magnifying glass and lenses.
6. Learn principle of refraction using prisms.
7. Check bending of light in different substances and find out what matters here.
8. Learn about different telescopes used to see galaxies and their ranges.

Semester VIII
Digital Systems (3 Credits)
PHY- MVC-801T

Full Marks: 75

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. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

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

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders.

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.

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).

Reference Books:

1. Digital Principles and Applications, A.P. Malvino, D. P. Leach and Saha, 7th Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Systems: Principles & Applications, R. J. Tocci, N. S. Widmer, 2001, PHI Learning
5. Logic circuit design, Shimon P. Vingron, 2012, Springer.
6. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
7. Digital Electronics, Floyd.
8. Digital Computer Electronics, Malvino

PHYSICS LAB- PHY- MVC-801P (1 credit) FM: 25

1. To design a switch (NOT gate) using a transistor.
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To design a combinational logic system for a specified Truth Table.
4. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
5. To minimize a given logic circuit.
6. Half Adder, Full Adder and 4-bit binary Adder.
7. Half Adder and Full Adder Truth table verification using I.C.

VII. Multi-disciplinary Course of three (2T + 1P) Credits each

(To be studied by students who have not opted Physics in major, minor and intermediate level / 10+2)

Semester II

Introductory Physics – (2 Credits)

PHY-MDC-201T

Full Marks: 50

Introduction: Units of physical quantities, Scalar and Vector quantities: Examples

Motion: Projectile motion, Circular Motion, Simple Harmonic Motion, Relative motion

Forces: Examples of contact forces (frictional force, normal reaction force, tension force as applied through strings and force exerted during collision) and non-contact forces (gravitational, electric and magnetic). General properties of non-contact forces. Conservative and non- conservative forces,

Newton's Laws of Motion: concept of inertia and some examples of it, examples of Newton's second and third laws, Work, Energy and Power

Gravitation: Universal Law of Gravitation. (Statement and equation) and its importance. Gravity, acceleration due to gravity, variation in g, free fall. Keplers law of planetary motion, orbital speed and period of satellite, Geo- stationary satellite, escape velocity

Elasticity: Hooke's Law and types of elastic constant

Wave: Longitudinal Wave, Transverse Wave, electromagnetic waves, Audible sound waves, Ultrasonic and Infrasonic waves, speed of sound, effect of temperature, pressure and humidity of speed, characteristics of sound waves, echo, resonance, interference of sound, stationary wave, diffraction of sound, Doppler's effect, Mach Number, Shock and bow waves.

Heat: Units of Heat, Temperature, Specific Heat capacity, Conduction, convection and radiation, Newton's Law of cooling, Kirchhoff's Law, Stefan's Law, Newton's Law of cooling, Change of state, Latent heat, relative humidity, Laws of Thermodynamics

Light: Refractive index, Reflection of Light, Refraction of Light, Total Internal Reflection, Dispersion, Rainbow, Theory of Classes, Scattering of Light, Interference of light, Diffraction of Light, Polarisation, Human Eye, Simple and compound microscopes, Electron microscope, Telescope

Electricity and Magnetism: Ohm's Law, concepts of emf, potential difference, resistance; resistances in series and parallel; internal resistance, Electrical power and energy. Household circuits (main circuit; switches; fuses; earthing, safety precautions; three-pin plugs; colour coding of wires); Magnetic effect of a current (principles only, laws not required); electromagnetic induction (elementary); transformer.

Nuclear Physics: properties of fundamental particles, Radioactivity, properties of alpha, beta and gamma rays, Nuclear fission and fusion, Nuclear reactor, Mass-Energy Relations

Electronics: Semiconductor, types, doping.

PHYSICS LAB- PHY-MDC-201P (1 credit) FM: 25

1. Measurements of length (or diameter) using Vernier caliper.
2. Measurements of length (or diameter) using screw gauge.
3. Measurements of length (or diameter) using travelling microscope.
4. To study the random error in observations.
5. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
6. Determination of g using simple pendulum.

Amrita Mukherjee 13.07.23

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