

FYUGP Physics Syllabus

Gauhati University

(Recommended by the meeting of the CCS in Physics held on 11.05.2026, the Joint Faculty meeting held on 20.05.2026 and the Academic Council held on 26.05.2026)



Department of Physics
Gauhati University
Guwahati, Assam,
India

FYUGP Physics

Program Outcome (PO)

On completion of the program, the students will acquire a strong foundation in theoretical and experimental physics. The students will develop practical skills through laboratory work and gain exposure to research methodologies through project dissertation and internships.

Program Specific Outcome (PSO)

After completion of the program, the students will be able to opt for teaching, entrepreneurship, research and higher studies in the frontiers of physics, R & D activities in defence, space, aeronautics and information technology in national and international organizations.

Programme name	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks	External Marks
						Lecture	Tutorial	Practical			
FYUGP in Physics (Major/Minor/Common courses)	10+2 or equivalent passed with pass mark in physics and mathematics	1	Mathematical Physics & Mechanics Major 1	PHY0100104	4	3	-	1		30	70
			Mathematical Physics & Mechanics Minor 1	PHY0100104	4	3	-	1		30	70
		2	Mathematical Physics & Electricity and Magnetism Major 2	PHY 0200104	4	3	-	1		30	70
			Mathematical Physics & Electricity and Magnetism Minor 2	PHY 0200104	4	3	-	1		30	70
		3	Waves and Optics Major 3	PHY 0300104	4	3	-	1		30	70
			Electromagnetic Theory Major 4	PHY0300204	4	3	-	1		30	70
			Waves and Optics	PHY 0300104	4	3	-	1		30	70

			Minor 3							
		4***	Classical Mechanics-I Major 5	PHY 0400104	4	3	1	-		40 60
			Quantum Mechanics-I Major 6	PHY 0400204	4	3	-	1		30 70
			Analog Electronics Major 7	PHY 0400304	4	3	-	1		30 70
			Mathematical Physics-I Major 8	PHY 0400404	4	3	-	1	Mathematical Physics in SEM I and II	30 70
			Analog Electronics Minor 4 (Compulsory)	PHY 0400304	4	3	-	1		30 70
			Classical Mechanics-I Minor 5	PHY 0400104	4	3	1	-		40 60
			Quantum Mechanics-I Minor 6	PHY 0400204	4	3	-	1		30 70
		5***	Atomic and Molecular Physics-I Major 9	PHY 0500104	4	3	1	-	Quantum Mechanics-I in SEM IV	40 60
			Condensed Matter Physics Major 10	PHY 0500204	4	3	-	1		30 70
			Heats & Thermodynamics Major 11	PHY 0500304	4	3	-	1		30 70
			Heats & Thermodynamics Minor 7	PHY 0500304	4	3	-	1		30 70
			Atomic and Molecular Physics-I Minor 8	PHY 0500104	4	3	1	-	Quantum Mechanics-I in SEM IV	40 60
			Condensed Matter Physics Minor 9	PHY 0500204	4	3	-	1		30 70
		6***	Nuclear & Particle Physics Major 12	PHY 0600104	4	3	1	-		40 60

			Digital Electronics Major 13	PHY 0600204	4	3	-	1	Analog Electronics	30	70
			Astronomy & Astrophysics-I Major 14	PHY 0600304	4	3	1	-		40	60
			Statistical Mechanics Major 15	PHY 0600404	4	3	1	-	Heat & Thermodynamics (or thermal physics) and Quantum Mechanics	40	60
			Digital Electronics Minor 10	PHY 0600204	4	3	-	1	Analog Electronics	30	70
			Nuclear & Particle Physics Minor 11	PHY 0600104	4	3	1	-		40	60
			Astronomy & Astrophysics-I Minor 12	PHY 0600304	4	3	1	-		40	60

***Please indicate the compulsory course for the students who took admission only with MINOR subjects. The FYUGP Curriculum and Credit Framework state that a student with MINOR subjects must complete 21 courses over a period of three years, with seven minor courses from each subject. This means a student with MINOR subjects must take two courses of a given subject either in the fourth, fifth, or sixth semesters. Therefore, **each department or centre must define the four required/compulsory courses during fourth to sixth semesters for students who have been admitted with MINOR subjects.**

Colleges can offer any AEC/SEC/MDC from the list approved by Gauhati University, as per available resources in their respective colleges.

A. FYUGP in Physics Honours (Semester VII and VIII)

Program me name	Eligibilit y Criteria of the program me, if any	Se m est er	Course name	Course code	credi ts	Credit distribution of the course			Pre- requisit e of the course (if any)	Internal marks	Extern al Marks
						Lectu re	Tutori al	Prac tical			
FYIMP in Physics (Honour s)	Physics as a MAJOR or MINOR Subject upto 3rd Year	7	Mathematical Physics-II	PHY470 0104MJ	4	3	1	0	Mathe matical Physics -I	40	60
			Quantum Mechanics-II	PHY470 0204MJ	4	3	1	0	Quantu m Mecha nics-I	40	60
			Electronics	PHY470 0304MJ	4	3	1	0	Analog Electro nics, Digital Electro nics		
			Research Methodology in Physics	PHY470 0404MJ	4	3	1	0		40	60
			Atomic and Molecular Physics-I Minor	PHY470 0704MN	4	3	1	-		40	60
		8	Atomic and Molecular Physics-II	PHY480 0104MJ	4	3	1	0	Atomic and Molecu lar Physics -I	40	60
			Condensed Matter Physics-	PHY480 0204MJ	4	3	1	0	Conden sed Matter	40	60

			II						Physics -I		
			Nuclear Physics-II	PHY480 0304MJ	4	3	1	0	Nuclear Physics -I	40	60
			Seminar Based on Laboratory work	PHY480 0404MJ	4	0	0	4		40	60
			Astronomy &Astrophysics- I	PHY480 0604MN	4	3	1	0		40	60
			Minor								

B. FYUGP in Physics Honours with Research (Semester VII and VIII)

Program me name	Eligibilit y Criteria of the program me, if any	Se m ester	Course name		Course code	credi ts	Credit distribution of the course			Pre-requisit e of the course (if any)	Internal marks	Extern al Marks
							Lectu re	Tutori al	Prac tical			
FYIMP in Physics (Honours)	Physics as a MAJOR or MINOR Subject upto 3rd Year	7	Mathematical Physics-II		PHY470 0104MJ	4	3	1	0	Mathe matical Physics -I	40	60
			Quantum Mechanics-II		PHY470 0204MJ	4	3	1	0	Quantu m Mecha nics-I	40	60
			Electronics		PHY470 0304MJ	4	3	1	0	Analog Electro nics, Digital Electro nics		
			Research Methodology in Physics		PHY470 0404MJ	4	3	1	0		40	60
			Atomic and Molecular Physics-I		PHY470 0704MN	4	3	1	-		40	60
			Minor									
		8	Choose any one paper in line with Dissertation Topic	Atomic and Molecular Physics-II	PHY480 0104MJ	4	3	1	0	Atomic and Molecu lar Physics -I	40	60
				Condensed Matter Physics	PHY480 0204MJ	4	3	1	0	Condensed Matter Physics	40	60

			s-II							-I		
			Nuclear Physics s-II	PHY480 0304MJ	4	3	1	0		Nuclear Physics -I	40	60
			Dissertation	PHY480 0712MJ	12	0	0					
			Astronomy &Astrophysics- I Minor	PHY480 0604MN	4	3	1	0			40	60

SEC Course

Programme name (AEC/ VAC/ MDC/ SEC)	Eligibility Criteria of the programme, if any	Semester	Course name	Course code	Credits	Credit distribution of the course			Pre-requisite of the course (if any)	Internal marks	External Marks
						L	T	P			
SEC	No	2	Workshop Practice		3	1	0	2		25	50

Semester wise breakup of courses and credits**Semester -I**

Course Code	Course name	Major/Minor	COURSE_CATEGORY	TYPE	Credit
PHY0100104	Mathematical Physics & Mechanics	MAJOR	COMPULSORY	THEORY	4
	Minor 1 (from Minor discipline)	MINOR	COMPULSORY	THEORY	4
	SEC-1 (Major oriented)	SEC	COMPULSORY	THEORY	3
	AEC-1 (Languages/Alt. English)	AEC	COMPULSORY	THEORY	4
	MDC-1	MDC	COMPULSORY	THEORY	3
	VAC-1	VAC	COMPULSORY	THEORY	2
				Total	20

Semester-II

Course Code	Course name	Major/Minor	COURSE_CATEGORY	TYPE	Credit
PHY0200104	Mathematical Physics & Electricity and Magnetism	MAJOR	COMPULSORY	THEORY	4
	Minor-2 (from Minor discipline)	MINOR	COMPULSORY	THEORY	4
	SEC-2 (Major oriented) - Workshop Practice	SEC	COMPULSORY	PRACTICAL	3
	AEC-2 (English Communication)	AEC	COMPULSORY	THEORY	4
	MDC-2	MDC	COMPULSORY	THEORY	3
	VAC-2	VAC	COMPULSORY	THEORY	2
				Total	20

Semester-III

Course Code	Course name	Major/Minor	COURSE_CATEGORY	TYPE	Credit
PHY0300104	Waves and Optics	MAJOR	COMPULSORY	THEORY	4
PHY0300204	Electromagnetic Theory	MAJOR	COMPULSORY	THEORY	4
	Minor-3 (from Minor discipline)	MINOR	COMPULSORY	THEORY	4
	SEC-3 #	SEC	COMPULSORY	THEORY	3
	MDC-3	MDC	COMPULSORY	THEORY	3
	VAC-3	VAC	COMPULSORY	THEORY	2
				Total	20

Semester-IV

Course Code	Course name	Major/Minor	COURSE_CATEGORY	TYPE	Credit
PHY0400104	Classical Mechanics-I	MAJOR	COMPULSORY	THEORY	4
PHY0400204	Quantum Mechanics-I	MAJOR	COMPULSORY	THEORY	4
PHY0400304	Analog Electronics	MAJOR	COMPULSORY	THEORY	4
PHY0400404	Mathematical Physics-I	MAJOR	COMPULSORY	THEORY	4
	Minor-4 (from Minor discipline)	MINOR	COMPULSORY	THEORY	4
				Total	20

Semester-V

Course Code	Course name	Major/Minor	COURSE_CATEGORY	TYPE	Credit
PHY0500104	Atomic and Molecular Physics-I	MAJOR	COMPULSORY	THEORY	4
PHY0500204	Condensed Matter Physics	MAJOR	COMPULSORY	THEORY	4
PHY0500304	Heat & Thermodynamics	MAJOR	COMPULSORY	THEORY	4
	Internship	INTERNSHIP	COMPULSORY	PRACTICAL	4
	Minor-5 (from Minor discipline)	MINOR	COMPULSORY	THEORY	4
				Total	20

Semester-VI

Course Code	Course name	Major/Minor	COURSE_CATEGORY	TYPE	Credit
PHY0600104	Nuclear & Particle Physics	MAJOR	COMPULSORY	THEORY	4
PHY0600204	Digital Electronics	MAJOR	COMPULSORY	THEORY	4
PHY0600304	Astronomy & Astrophysics-I	MAJOR	COMPULSORY	THEORY	4
PHY0600404	Statistical Mechanics-I	MAJOR	COMPULSORY	THEORY	4
	Minor-6 (from Minor discipline)	MINOR	COMPULSORY	THEORY	4
				Total	20

Semester-VII

Course Code	Course name	Major/Minor	COURSE_CATEGORY	TYPE	Credit
PHY0700104MJ	Mathematical Physics-II	MAJOR	COMPULSORY	THEORY	4
PHY0700204MJ	Quantum Mechanics-II	MAJOR	COMPULSORY	THEORY	4
PHY0700304MJ	Electronics	MAJOR	COMPULSORY	THEORY	4
PHY0700404MJ	Research Methodology in Physics	MAJOR	COMPULSORY	THEORY	4
	Minor-7 (from Minor discipline)	MINOR	COMPULSORY	THEORY	4
				Total	20

Semester-VIII (Honours)

Course Code	Course name	Major/Minor	COURSE_CATEGORY	TYPE	Credit
PHY0800104MJ	Atomic and Molecular Physics-II	MAJOR	COMPULSORY	THEORY	4
PHY0800204MJ	Condensed Matter Physics-II	MAJOR	COMPULSORY	THEORY	4
PHY0800304MJ	Nuclear Physics-II	MAJOR	COMPULSORY	THEORY	4
PHY0800404MJ	Seminar Based on Laboratory work	MAJOR	COMPULSORY	PROJECT	4
	Minor-8 (from Minor discipline)	MINOR	COMPULSORY	THEORY	4
				Total	20

Semester-VIII (Honours with Research)

Course Code	Course name	Major/Minor	COURSE CATEGORY		TYPE	Credit
PHY0800104MJ	Atomic and Molecular Physics-II	MAJOR	ELECTIVE	Choose Any One	THEORY	4
PHY0800204MJ	Condensed Matter Physics-II	MAJOR				
PHY0800304MJ	Nuclear Physics-II	MAJOR				
PHY4800712MJ	Dissertation	MAJOR	COMPULSORY		PROJECT	12
	Minor-8 (from Minor discipline)	MINOR	COMPULSORY		THEORY	4
					Total	20

**Four Year Undergraduate Programme in Physics
Semester-I**

Paper Name: Mathematical Physics& Mechanics

Paper Code: PHY0100104

Total number of lectures: 45

Total credit: 4 (Theory 3 +Laboratory 1)

Total Marks: 100 (45 (Th) +25 (Lab) +30 (Int))

Course Outcomes:

CO 1: Recognise physical problems where mathematical methods are used.

CO 2: Interpret the results of calculation.

CO 3: Solve problems in mechanics with the help of mathematical frameworks

CO 4: Integrate different mathematical concepts to understand dynamics of particles.

CO 5: Test applicability of mechanics to realise physical problems.

Part A

Mathematical Physics (Credit=1; Lectures=15)

Contents:

Unit-I: Vector calculus (8 L)

Scalar and vector fields. Derivatives of vector functions (physical examples - velocity, centripetal acceleration of a point in circular motion). Gradient of a scalar field (example of Newton's gravitational force as gradient of a scalar potential). Gradient as normal vector to a surface. Divergence and curl of a vector field- solenoidal and irrotational vector fields. Laplacian operator (physical problems –Laplacian of gravitational potential, divergence of central force). Vector identities.

Vector integration- Line integral (physical example- work done by a force, path dependence/independence and concept of conservative force). Surface and volume integrals. Concept of vector flux. Gauss's divergence theorem and Stokes's theorem (statement only).

Unit-II: Curvilinear coordinates (5 L)

Introduction to curvilinear coordinates. Orthogonal curvilinear coordinates. Examples of spherical, cylindrical and plane polar coordinates. Line element- transformation from Cartesian to curvilinear coordinates (spherical and cylindrical). Gradient, divergence and curl in spherical and cylindrical coordinates.

Unit-III: Dirac delta function (2 L)

Definition and properties of Dirac delta function. Representation of delta function by Gaussian function, rectangular function and Laplacian of $1/r$.

Part B
Mechanics (Credit=2; Lectures=30)

Unit-I: Reference frames (4 L)

Inertial frames. Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications.

Unit-II: Gravitation and central force motion (7 L)

Motion under central force. Two-body problem and its reduction to one body problem. Kepler's laws, Gravitational potential and fields due to spherical body. Gauss's law and Poisson's equation for gravitational field.

Unit-III: Work and energy, Conservation laws and Collision (7 L)

Work and kinetic energy theorem. Conservative and non-conservative forces. Potential energy. Force as gradient of potential energy. Work and potential energy. Work done by non-conservative forces. Dynamics of a system of particles. Centre of mass. Principle of conservation of momentum. Torque. Impulse. Elastic and inelastic collisions between particles. Centre of mass and laboratory frames.

Unit-IV: Dynamics of rigid bodies (6 L)

Rigid body motion. Rotational motion. Moment of inertia of rectangular lamina, disc, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Unit-V: Properties of matter (6 L)

Relation between elastic constants. Twisting torque on a cylinder or wire. Cantilever. Kinematics of moving fluids: Poiseuille's equation for flow of a liquid through a capillary tube.

Laboratory (Credit =1)

The students are required to perform at least four experiments from the following list of experiments.

1. To study the motion of spring and calculate (a) spring constant and (b) rigidity modulus.
2. To determine the moment of inertia of a cylinder about two different axes of symmetry by torsional oscillation method.
3. To determine coefficient of viscosity of water by capillary flow method (Poiseuille's method).
4. To determine the Young's modulus of the material of a wire by Searle's apparatus.
5. To determine the modulus of rigidity of a wire (static method).
6. To determine the value of g using bar pendulum.
7. To determine the value of g using Kater's pendulum.
8. To determine the height of a building using a sextant.
9. To determine g and velocity for a freely falling body using digital timing technique.

References:

1. Essential Mathematical Methods for the Physical Sciences; K.F. Riley and M.P. Hobson, Cambridge University Press.
2. Advanced Engineering Mathematics; E. Kreyszig, John Wiley & Sons (New York).
3. Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.
4. Mathematical Physics-I, K. K Pathak and S. Parasher, Vishal Publication, Jalandhar (Delhi).
5. Theoretical Mechanics, M. R. Spiegel, Tata McGraw Hill.
6. Mechanics; D. S. Mathur, S. Chand & Company Limited.
7. An Introduction to Mechanics, D. Kleppner and R. J. Kolenkow, Tata McGraw-Hill.
8. Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al., Tata McGraw-Hill.
9. Physics, R. Resnick, D. Halliday and J. Walker, John Wiley & Sons.
10. Analytical Mechanics, G. R. Fowles and G. L. Cassiday, Cengage Learning.
11. Feynman Lectures, Vol. I, R. P. Feynman, R. B. Leighton and M. Sands, Pearson Education.
12. University Physics, F. W. Sears, M. W. Zemansky and H.D Young, Addison Wesley
13. Physics for Scientists and Engineers with Modern Phys., J. W. Jewett and R. A. Serway, Cengage Learning.
14. Mechanics, D. Sarma and K. K Pathak, Vishal Publications, Jalandhar (Delhi).

Four Year Undergraduate Programme in Physics

Semester-II

Paper Name: Mathematical Physics & Electricity and Magnetism

Paper Code: PHY0200104

Total number of lectures: 45

Total credit: 4 (Theory3 +Laboratory 1)

Total Marks: 100 (45 (Th) +25 (Lab) +30 (Int))

Course outcomes:

- CO1:** Recall fundamental concepts of differential equations, matrix properties, electric and magnetic fields, and electrical circuits, including key definitions, laws, and theorems.
- CO2:** Explain the physical principles behind differential equations, matrix applications, electrostatics, magnetostatics, and AC circuits with practical examples.
- CO3:** Solve problems related to the behaviour of systems governed by differential equations, electric and magnetic fields, and circuit theorems using appropriate mathematical tools.
- CO4:** Examine and differentiate the characteristics of physical systems such as LCR circuits, magnetic materials, and dielectric properties under varying conditions.
- CO5:** Design and perform laboratory experiments to measure physical quantities, verify theoretical principles, and interpret results to draw meaningful conclusions about electromagnetic systems and circuits

Part A

Mathematical Physics (Theory)

Credit = 1

Contents:

Unit-I: Differential equations (10 L)

First and second order ordinary differential equations (ODE). Homogeneous and inhomogeneous differential equations. Solutions of first order ODE – integrating factors (physical examples – radioactive decay, Newton's law of cooling, particle falling under gravity through a resistive medium). Concept of initial/boundary conditions. Solutions of second order ODE with constant coefficients- complementary function and particular integral (physical examples- simple harmonic oscillation, forced vibration). Wronskian- definition and its use to check linear independence.

Partial differential equations (PDE) (physical examples – wave equation, diffusion equation, Laplace and Poisson equation – introduction only). Exact and inexact differentials. Concept of variable separation in a PDE.

Unit-II: Matrices (5 L)

Properties of matrices. Determinant and rank. Transpose and complex conjugate of matrices. Hermitian and anti-Hermitian matrices. Unitary and orthogonal matrices. Representation of linear homogeneous and inhomogeneous equations through matrix equation. Inverse of a matrix. Eigen values and eigen-vectors. Cayley-Hamilton Theorem (statement only), Diagonalisation of simple matrices.

Part B
Electricity and Magnetism (Theory)
Credit = 2

Unit-I: Electric field and electric potential (13 L)

Electrostatic field, electric flux. Gauss's law. Application of Gauss's law to charge distributions with planar, spherical and cylindrical symmetries. Conservative nature of electrostatic field. Electrostatic potential. Electrostatic energy of a system of charges. Electrostatic boundary conditions. Laplace's and Poisson's equations. Uniqueness theorem. Application of Laplace's equation involving planar, spherical and cylindrical symmetries. Potential and electric field of a dipole. Force and torque on a dipole. Capacitance of a system of charged conductors: parallel plate, spherical and cylindrical. Capacitance on an isolated conductor.

Unit-II: Dielectric properties of matter (4 L)

Electric field in matter. Polarisation, polarisation charges. Electrical susceptibility and dielectric constant. Capacitor (parallel plate, spherical and cylindrical) filled with dielectric. Displacement vector, $\vec{D}$. Relation between $\vec{E}$, $\vec{P}$ and $\vec{D}$. Gauss's law in dielectrics.

Unit-III: Magnetic field (6 L)

Magnetic force on a point charge, definition and properties of magnetic field $\vec{B}$. Curl and divergence. Vector potential, $\vec{A}$. Magnetic scalar potential. Magnetic force on (i) a current carrying wire and (ii) between two elements. Torque on a current loop in a uniform magnetic field. Biot-Savart's law and its simple application: 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 (i) solenoid and (ii) torus.

Unit-IV: Magnetic properties of matter (2L)

Magnetization vector, $\vec{M}$. Magnetic intensity, $\vec{H}$. Magnetic susceptibility and permeability. Relation between $\vec{B}$, $\vec{H}$ and $\vec{M}$. Ferromagnetism. B-H curve and hysteresis.

Unit-V: Electrical circuits (5 L)

AC circuits: Kirchhoff's laws for AC circuits. Complex reactance and inductance. Series LCR circuits and parallel LCR circuits: (i) phasor diagram, (ii) resonance, (iii) power dissipation, (iv) quality factor, and (v) band width. Ideal constant-voltage and constant-current sources. Thevenin theorem and Norton theorem (only statements and solving of related problems).

Laboratory (Credit = 1)

The students are required to perform at least four experiments from the following list of experiments.

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De' Sauty's bridge.
6. Measurement of field strength $\vec{B}$ and its variation in a solenoid (determine $\frac{dB}{dx}$).
7. To verify the Thevenin and Norton Theorems.
8. To verify the superposition and maximum power transfer theorems.
9. To determine the self-inductance of a coil by Anderson's bridge.
10. To study the response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer.
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine the self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by the Absolute method.

Reference books:

1. Essential Mathematical Methods for the Physical Sciences; K.F. Riley and M.P. Hobson, Cambridge University Press.
2. Advanced Engineering Mathematics; E. Kreyszic, John Wiley & Sons (New York)
3. Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier

4. Mathematical Physics-I; Krishna K. Pathak and Sangeeta Prasher, Vishal Publishing Co, Jalalandhar (Delhi).
5. Mathematical Physics, H. K. Dass and Dr. Rama Verma, S. Chand Publication.
6. Introduction to Electrodynamics, D. J. Griffiths.
7. Electricity and Magnetism [With electromagnetic theory and special theory of relativity], D. Chattopadhyay and P. C. Rakshit, 2013, New Central Book Agency (P) Limited.
8. Electricity, Magnetism and Electromagnetic Theory, S. Mahajan and S. R. Choudhury, 2012, Tata McGraw.
9. Schaum's outline of Theory and Problems of Electromagnetics, J. A. Edminister.
10. Electromagnetics, B. B. Laud, New Age International Publishers.
11. Feynman Lectures Vol. 2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
12. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
13. Elements of Electromagnetics, M. N. O. Sadiku, 2008. Pearson Education.
14. Electricity and Magnetism, J. W. Fewkes and J. Yarwood, Vol. I, 1991, Oxford Univ. Press.

Four Year Undergraduate Programme in Physics
Semester - II
Paper Name: Basic Workshop Skills in Physics and Electronics
Paper Code: SEC
Total number of lectures: 30
Total credit: 3 (Theory 2 +Practical 1)
Total Marks: (30 (Th) +20(Lab) +25 (Int))

Course Outcomes:

- CO1:** Identify and understand the functions of basic electronic components.
- CO2:** Test and evaluate components for their functionality.
- CO3:** Simulate circuit layouts using software tools.
- CO4:** Design PCB layouts.
- CO5:** Develop, test, and validate electronic circuits.

Contents:

Unit-I: Introduction to Electronic components (10 L)

Identification of basic electronic components: Resistors, Capacitors, Diodes, Transistors, Integrated circuits (ICs), study datasheets and specifications.

Unit-II: Component Testing and electronic soldering (5 L)

Tools for component testing: multimeter, CRO, DSO, etc., testing passive and active components, soldering and de-soldering techniques.

Unit-III: Hands on skill (5 L)

Basics of PCB design, introduction to software tools, PCB fabrication techniques, design and simulate electronic circuits on breadboard and general purpose PCB.

Unit-IV: Introduction to advanced electronic techniques (10 L)

Basics of fabrication technology: semiconductor devices, printed electronics, and flexible devices, demonstration of sophisticated analytical tools and techniques, use of 3D printing tool and software

**Four Year Undergraduate Programme in Physics
Semester - III**

Paper Name: Wave and Optics

Paper Code: PHY0300104

Total Number of Lectures: 45

Total Credits: 4 (Theory 3+ Laboratory 1)

Total Marks: 100 (45 (Th) +25 (Lab) +30 (Int))

Course Outcomes:

- CO1:** Understand the superposition of harmonic waves, oscillations, types of wave motions, standing waves, and wave velocity in different media.
- CO2:** Apply physical concepts to explain the behaviour and propagation of light waves.
- CO3:** Analyse optical phenomena such as interference, diffraction, and polarization using the wave model.
- CO4:** Evaluate and explain the principles and applications of optical instruments like biprism, interferometer, and diffraction grating.
- CO5:** Outline the basic concepts of fibre optics.

Contents:

Unit-I: Superposition of harmonic oscillations (4 L)

Superposition of waves: Linearity and Superposition principle, Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats), Lissajous figures and their use.

Unit-II: Wave motion (4 L)

Waves: Progressive (Travelling) Waves, wave equation, plane wave and spherical wave, Longitudinal and Transverse Waves, dispersion, group velocity, phase velocity, Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave.

Unit-III: Velocity of waves (4 L)

Velocity of Waves: 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.

Unit-IV: Superposition of two harmonic waves (9 L)

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes.

Unit-V: Wave optics (4 L)

Wave optics: Electromagnetic nature of light, definition and properties of wave front. Huygens principle. Temporal and Spatial coherence.

Unit-VI: Interference (4 L)

Division of wavefront and amplitude, intensity distribution in an interference pattern, Young's double slit experiment, Fresnel's Biprism. Phase change on reflection: Stokes' treatment, Interference in Thin Films: parallel and wedge-shaped films, Newton's Rings: Measurement of wavelength and refractive index, Michelson interferometer.

Unit-VII: Diffraction and Polarization (8 L)

Fresnel and Fraunhofer diffraction. Fresnel's Half-Period Zones for Plane Wave. Fresnel diffraction pattern of a straight edge and at a circular aperture. Fraunhofer diffraction: Single slit. Double slit. Diffraction grating. Resolving power of grating. Production of polarized light by reflection, refraction and scattering.

Unit-VIII: Optical Fibres (3 L)

Numerical Aperture, Step and Graded Indices (Definitions Only), Single and Multiple Mode Fibres (Concept and Definition Only).

Laboratory (Credit =1)

A minimum of four experiments to be done.

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 -T law.
2. Study of Lissajous Figure of two different waves using CRO and find out the unknown frequency of an electrical signal.
3. Familiarization with: Schuster's focusing, determination of angle of prism.
4. To determine refractive index of the Material of a prism using sodium source.
5. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
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 thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
9. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
10. To determine dispersive power and resolving power of a plane diffraction grating.

Reference books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
3. Vibrations and Waves in Physics, 2nd edition, I. G. Main, 1984, Cambridge University Press.
4. A Textbook of Sound, 3rd Edition, A. B. Wood, 1955, Bell & Sons.
5. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
6. Fundamentals of Optics, F. A. Jenkins and H.E. White, 1981, McGraw-Hill
7. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
8. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
9. Principles of Optics, B. K. Mathur and T. P. Pandya, 1981, Tata McGraw-Hill International.
10. Fundamental of Optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand Publications.

Four Year Undergraduate Programme in Physics

Semester - III

Paper Name: Electromagnetic Theory

Paper Code: PHY0300204

Total Number of Lectures: 45

Total Credits: 4 (Theory 3+ Laboratory 1)

Total Marks: 100 (45 (Th) +25 (Lab) +30 (Int))

Course outcomes:

CO1: Extend the ideas of electricity and magnetism to formulate the Maxwell's equations.

CO2: Illustrate the behaviour of electromagnetic waves as it propagates through vacuum and other media.

CO3: Analyze the various effects that occur as electromagnetic waves propagate from one medium to another one.

CO4: Explain different aspects of electromagnetic wave polarization.

Contents:

Unit - I: Maxwell's equations (10 L)

Maxwell's equations, Displacement Current, Vector and Scaler Potentials, Gauge Transformations: Coulomb and Lorentz Gauge, Boundary Conditions at Interface between Different Media, Poynting Theorem and Poynting Vector.

Unit - II: EM Wave Propagation (20 L)

Plane EM Waves through Vacuum and Isotropic Dielectric Medium, Transverse Nature of Plane EM Waves, Refractive Index and Dielectric Constant, Propagation through Conducting Media, Relaxation Time, Skin Depth. Wave Propagation through Dilute Plasma (Basic Concepts). Reflection and Refraction of Plane EM Waves at Plane Interface between two Dielectric Media – Laws of Reflection and Refraction, Fresnel's Formula for Parallel Polarization Case, Brewster's Law, Reflection and Transmission Co-efficients, Waveguides: Basic Concepts and Propagation of EM Waves in a Rectangular Waveguide.

Unit - III: Polarization of Electromagnetic Waves (11 L)

Description of Linear, Circular and Elliptical Polarization, Propagation of EM Waves in Anisotropic Media, Symmetric Nature of Dielectric Tensor, Fresnel's Formula, Uniaxial and Biaxial Crystals, Light Propagation in Uniaxial Crystal, Double Refraction, Polarization by Double Refraction, Nicol Prism; Ordinary & Extraordinary Refractive Indices, Production & Detection of Plane, Circularly and Elliptically Polarized Light; Phase Retardation Plates:

Quarter-Wave and Half-Wave Plates, Babinet Compensator and its Uses, Analysis of Polarized Light.

Unit - IV: Rotary Polarization (4 L)

Optical Rotation, Biot's Laws for Rotatory Polarization, Fresnel's Theory of Optical Rotation, Calculation of Angle of Rotation, Experimental Verification of Fresnel's Theory, Specific rotation, Laurent's Half-shade Polarimeter.

Laboratory (Credit =1)

A minimum of four experiments to be done.

1. To verify the law of Malus for plane polarised light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarised light by using Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection and refraction of microwaves.
7. To study polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarisation of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan's law of radiation and to determine Stefan's constant.
12. To determine the Boltzmann constant using V-I characteristic of pn junction diode.

Reference books:

1. Introduction to Electrodynamics, D. J. Griffiths.
2. Electromagnetics, B. B. Laud, New Age International Publishers.
3. Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
4. Introduction to Electromagnetic Theory, T. L. Chow, 2006, Jones & Bartlett Learning.
5. Feynman Lectures Vol. 2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
6. Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill.
7. Electromagnetic Field Theory, R. S. Kshetrimayun, 2012, McGraw Hill.
8. Engineering Electromagnetic, William H. Hayt, 2012, McGraw Hill.
9. Electricity and Magnetism [With electromagnetic theory and special theory of relativity], D. Chattopadhyay and P. C. Rakshit, 2013, New Central Book Agency (P) Limited.

Four Year Undergraduate Programme in Physics

Semester - IV

Paper Name: Classical Mechanics-I

Paper Code: PHY0400104

Total Number of Lectures: 60 (45 L+15 T)

Total Credits: 4 (Theory 3+ Tutorial 1)

Total Marks: 100 (60 (Th) +40 (Int))

Course Outcomes:

CO 1: Recognise the physical concepts required for classical mechanics

CO 2: Classify different formalisms of classical mechanics

CO 3: Solve problems in physics by using formalisms of classical mechanics

CO 4: Organise the concepts to learn new aspects

CO 5: Test the applicability of classical mechanics

Contents:

Unit-I: Mechanics of point particles-the Lagrangian approach (12 L + 4 T)

Review of Newtonian mechanics; system of particles and constrained motion with types of constraints; degrees of freedom, generalised coordinates and velocities; principle of virtual work and D'Alembert's principle; Lagrange's (Euler-Lagrange, EL) equation; Hamilton's principle; physical problems– simple and compound pendulums, simple harmonic oscillation, Lagrange's equations for a particle in spherical and cylindrical coordinate systems, falling body in uniform gravitational field, Lagrangian in central force problem.

Unit-II: Mechanics of point particles – the Hamiltonian approach (11 L + 4 T)

Generalised momenta; Legendre transformation; Hamilton's canonical equations; Hamiltonian from the Lagrangian; conservation of energy and momentum; physical problems – Hamiltonian for simple pendulum, canonical equations for a particle moving in central force field (gravitational potential).

Unit-III: Small oscillation (7 L + 2 T)

Minimum of potential energy and concept of stable equilibrium; expansion of potential energy around a minimum; kinetic and potential energy matrices; equation of motion of small oscillation.

Unit-IV: Special theory of relativity (15 L + 5 T)

Inadequacy of Galilean transformation; postulates of special relativity; Lorentz transformation; simultaneity and order of events; length contraction and time dilation; relativistic addition of velocities; variation of mass with velocity and mass-energy equivalence. Lorentz transformation as a rotation in spacetime; relation between proper time and coordinate time; relativistic kinematics: energy-momentum relation.

Reference books:

1. Classical Mechanics, H. Goldstein, C.P. Poole and J.L. Safko (Pearson Education)
2. Theoretical Mechanics, M. R. Spiegel (McGraw Hill Book Company)
3. Classical Mechanics, P.S. Joag and N.C Rana (McGraw Hill Book Company)
4. Mathematical Physics, B. S. Rajput (Pragati Prakashan)
5. Classical Mechanics, T.W.B. Kibble and F.H. Berkshire (Imperial College Press)
6. Mechanics: Courses in Theoretical Physics (Vol. 1), L.D. Landau and E.M. Lifshitz (Butterworth-Heinemann) (3rd Edn.)
7. Classical Mechanics: With introduction to non-linear oscillations and chaos, V.B. Bhatia (Narosa Publishing House)

Four Year Undergraduate Programme in Physics

Semester- IV

Paper Name: Quantum Mechanics I

Paper Code: PHY0400204

Total Number of Lectures: 45

Total Credits: 4 (Theory 3+ Laboratory 1)

Total Marks: 100 (45 (Th) +25 (Lab) +30 (Int))

Course Outcomes:

CO 1: Recall key quantum theory concepts (blackbody radiation, photoelectric effect, wave-particle duality).

CO 2: Explain principles of uncertainty, matter waves, and Schrödinger's equations.

CO 3: Solve problems involving operators, eigenvalues, and the uncertainty principle.

CO 4: Analyze quantum systems (infinite potential well, harmonic oscillator) for energy levels and probability distributions.

CO 5: Model and predict quantum phenomena like tunnelling and particle in a spherically symmetric potential.

Contents:

Unit-I: Origin of Quantum Theory (3 L)

Failure of classical theories, Explanation of blackbody radiation, Photoelectric effect, Compton Effect, particle nature of radiation, Bohr's correspondence principle.

Unit-II: Matter Wave and Wave-Particle Duality (5 L)

Wave-particle duality and de Broglie wavelength, particle as matter wave, wave description of particles by wave packets; phase and group velocity; Experimental verification of matter wave, Davisson and Germer experiment; two slit experiments with electrons and photons

Unit-III: Schrödinger Equation and Wavefunction (7 L)

Time dependent Schrödinger Equation, Time independent Schrödinger Equation; Physical interpretation and properties of wavefunction, continuity of a wavefunction, boundary conditions and emergence of discrete and continuous energy levels; probabilities and normalization in one and three dimensions; equation of continuity, probability current density in both one and three dimensions.

Unit-IV: Stationary States and General Solutions (5 L)

Stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrödinger equation, wavefunction of a free particle, Gaussian wave group in one dimension, Fourier transforms and momentum space wavefunction.

Unit-V: Dynamical Variables as Operators (4 L)

Different types of operators and their properties, position, momentum and energy operators; eigenvalue and eigenfunctions; expectation value of an operator, orthonormality condition, Ehrenfest's theorem; Commutation relations; introductory concept of Hilbert space, Dirac notation.

Unit-VI: Heisenberg's Uncertainty Principle and its Applications (6 L)

Uncertainty principle from wave packet description; Simultaneous measurement; general statement of Heisenberg's uncertainty principle, different uncertainty relations for non-commuting operators; applications of the position-momentum uncertainty principle, application of energy-time uncertainty principle; virtual particles and range of interaction.

Unit-VII: Applications of Time Independent Schrödinger Equation (15 L)

Particle in a one-dimensional infinite potential well, particle in a one-dimensional finite square potential well, barrier penetration problems – potential step and rectangular potential barrier (tunneling effect), linear harmonic oscillator, spherically symmetric potential, hydrogen atom – radial solution, spherical harmonics, angular momentum operator and different quantum numbers, radial distribution function and shapes of the probability densities for ground & first excited states; degeneracy of states : s, p, d states

Laboratory (Credit =1)

A minimum of four experiments to be done.

1. Measurement of Planck's constant using blackbody radiation and photodetector.
2. Photoelectric effect: Photocurrent versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least four different colours.
5. To determine the wavelength of H_{α} emission line of hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of iodine vapour.
8. To determine the value of e/m by (a) magnetic focusing or (b) bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunnelling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction from single slit.
12. To determine the wavelength of laser source using diffraction from double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.

Suggested Books

1. N. Zettili, Quantum Mechanics, John Wiley & Sons (2001).
2. J. J. Sakurai and J. Napolitano, Modern Quantum Mechanics, Cambridge Univ. Press, 2020.
3. Y. R. Waghmare, Fundamentals of Quantum Mechanics, Wheeler publishing (2014).
4. B. H. Bransden and C. J. Joachain, Quantum Mechanics, Pearson Education 2nd Ed. (2004).
5. D. J. Griffiths, Introduction to Quantum Mechanics, Pearson Education (2005).
6. A. K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Applications, Springer (2002).
7. A. Bieser, Concepts of Modern Physics, McGraw Hill (2002).
8. H. C. Verma, Quantum Mechanics, TBS publications (2019).

**Four Year Undergraduate Programme in Physics
Semester-IV**

Paper Name: Analog Electronics

Paper Code: PHY0400304

Total number of lectures: 45

Total credit: 4 (Theory 3 +Laboratory 1)

Total Marks: 100 (45 (Th) +25 (Lab) +30 (Int))

Course Outcomes:

CO1: Recall the basic theory of PN Junction Diode.

CO2: Explain the working of different electronic components like diodes, transistors, and Op- Amps.

CO3: Classify various electronic circuits like rectifiers, amplifiers and oscillators.

CO4: Design different circuits related to Op-Amp (IC 741).

CO5: Interpret the basic use of CRO

Contents:

Unit-I: Semiconductor Diodes (7 L)

P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width, and Current for Step Junction.

Unit-II: Two-terminal Devices and their Applications (5 L)

Rectifier Diode: Half- wave Rectifiers. Centre-tapped and Bridge type Full-wave Rectifiers. Calculation of Ripple Factor and Rectification Efficiency. C-filter. Zener Diode and Voltage Regulation. Power supply without filter circuit and with C-filter circuit. Principle LEDs, Photodiode, and Solar Cell (Basic concept).

Unit-III: Bipolar Junction Transistors (5 L)

n-p-n and p-n-p Transistors. Characteristics of CB, CE, and CC Configurations. Current gains α and β . Relations between α and β . Load line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff, and Saturation Regions.

Unit-IV: Amplifiers (7 L)

Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as a 2-port Network. h-parameter. Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage, and Power Gains. Classification

of Class A, B & C Amplifiers (Basic Concept). Differential amplifier using transistor (Working Principle Only).

Unit-V: Coupled Amplifier (2 L)

Two-stage RC-coupled amplifier and its frequency response.

Unit-VI: Feedback in Amplifiers (4 L)

Effects of Positive and Negative Feedback on Input Impedance. Output Impedance. Gain. Stability. Distortion and Noise.

Unit-VII: Sinusoidal Oscillators (5 L)

Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator.

Unit-VIII: Operational Amplifiers (Black Box approach) (3 L)

Characteristics of an Ideal and Practical Op-Amp (IC 741). Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and Concept of Virtual Ground.

Unit-IX: Applications of Op-Amps (4 L)

Inverting and non-inverting amplifiers. Adder. Subtractor. Differentiator. Integrator. Log and Anti Log amplifier. Comparator.

Unit X: Introduction to CRO (3 L)

Block Diagram of CRO and working principle

Laboratory (Credit =1)

A minimum of four experiments to be done.

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 a voltage regulator.
3. Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal Class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of an RC-coupled transistor amplifier.
8. Design a Wien bridge oscillator for a given frequency.
9. To design a phase shift oscillator of given specifications using BJT.
10. To design an inverting amplifier using Op-amp for the DC voltage of a given gain.
11. To design inverting amplifier using Op-amp and study its frequency response.
12. To design a non-inverting amplifier using Op-amp and study its frequency response.
13. To study the zero-crossing detector and comparator.

14. To add two DC voltages using Op-amp in inverting and non-inverting modes.
15. To design a precision Differential amplifier of given I/O specification using Op-amp.
16. To investigate the use of an Op-amp as an Integrator.
17. To investigate the use of an Op-amp as a Differentiator.
18. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO. Construct a series LR circuit. Display the two waveforms on the CRO and measure the phase differences between the voltages across R and L.
19. To test a Diode and Transistor using a Multimeter. Draw the forward bias characteristic of the diode. Using only the base-emitter junction of the transistor draw a characteristic curve and show that it behaves as a forward-biased diode.

Note: All students will have to do an electronic project on the circuits, for example, the power supply, the AM detector, etc. to get acquainted.

Suggested Books

1. Integrated Electronics, J. Millman and C. C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J. D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B. G. Streetman & S. K. Banerjee, 6th Edn., 2009, PHI Learning
4. Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata McGraw Hill
5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
6. Microelectronic circuits, A. S. Sedra, K.C. Smith, A. N. Chandorkar, 2014, 6th Edn., Oxford University Press.
7. Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk, 2008, Springer
8. Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd Ed., 2002, Wiley India
9. Microelectronic Circuits, M. H. Rashid, 2nd Edition, Cengage Learning
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
11. Electronics Fundamentals and Applications, D. Chattopadhyay and P. C. Rakshit, 17th Ed, 2023, New Age International Publishers

**Four Year Undergraduate Programme in Physics
Semester - IV**

Paper Name: Mathematical Physics-I

Paper Code: PHY0400404

Total number of lectures: 45

Total credits: 4 (Theory 3 +Laboratory 1)

Total Marks: 100 (45 (Th) +25 (Lab) +30 (Int))

Course Outcomes:

- CO1:** Recall and identify key concepts of partial differential equations, Fourier series, complex analysis, and probability distributions.
- CO2:** Explain the principles and methodologies used in solving partial differential equations, expanding periodic functions into Fourier series, and analyzing complex variables.
- CO3:** Solve problems involving partial differential equations, Fourier series in physical and mathematical contexts.
- CO4:** Analyze the behaviour of complex functions, their singularities, and the properties of tensors and probability distributions in theoretical and applied scenarios.
- CO5:** Design and implement computational solutions to mathematical problems using programming tools such as C/C++, Scilab, FORTRAN, Mathematica, Matlab, or Python.

Contents:

Unit-I: Partial Differential Equations (10 L)

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

Unit-II: Fourier Series (7 L)

Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Application to square and triangular waves.

Unit-III: Complex Analysis (15 L)

Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity. Integration of functions with complex variable. Cauchy's Integral theorem and Cauchy's Integral formula. Simply and multiply connected regions. Laurent and Taylor's series expansions. Residue Theorem with application.

Unit-IV: Special Functions (8 L)

Frobenius Method of series solution of DE. Legendre DE, Legendre polynomials, Associated Legendre Polynomials, Spherical Harmonics, Hermite polynomials, Bessel functions, Laguerre polynomials; Gamma and Beta functions; Green's function.

Unit-V: Introduction to Probability (5 L)

Independent random variables: Probability distribution functions; binomial, Gaussian and Poisson, with examples. Mean and variance.

Laboratory (Credit =1)

(Use C/C++/Scilab/FORTRAN/Mathematica/ Matlab/ Python to solve the following problems.)

1. Solve the differential equations

$$\frac{dy}{dx} = e^x \text{ with } y=0 \text{ for } x=0$$

$$\frac{dy}{dx} + e^x y = x^2$$

$$\frac{d^2 y}{dx^2} + 2 \frac{dy}{dx} = -y$$

$$\frac{d^2 y}{dx^2} + e^x \frac{dy}{dx} = -y$$

2. Perform the multiplication of two 3×3 matrices.
3. Compute the eigenvalues and eigenvectors of the following matrices.

$$\begin{bmatrix} 4 & 3 & 7 \\ 1 & 2 & 7 \\ 2 & 0 & 4 \end{bmatrix}, \begin{bmatrix} 1 & -i & 3+4i \\ i & 2 & 4 \\ 3-4i & 4 & 3 \end{bmatrix}, \begin{bmatrix} 2 & -i & 2i \\ i & 4 & 3 \\ -2i & 3 & 5 \end{bmatrix}$$

4. Using random number compute the areas of circle, square, volume of sphere and value of pi (π).
5. Evaluate trigonometric functions e.g. $\sin\theta$; $\cos\theta$; $\tan\theta$ etc. using Interpolation by Newton Gregory Forward and Backward difference formula.
6. Find the solution of Partial Differential Equations: (a) Wave equation (b) Heat equation.
7. Evaluate the integral I , where, $I = \frac{1}{\sqrt{2\pi\sigma^2}} \int \exp\left[-\frac{(x-2)^2}{2\sigma^2}\right] (x+3) dx$ for $\sigma=1.0, 0.1, 0.01$ and show that $I \rightarrow 5$
8. Compute the n th roots of unity for $n = 2, 3$, and 4 .
9. Find the two square roots of $5 + 12i$.

Reference Books:

1. Mathematical Physics; H K Dass and R Verma, S Chand and Company limited.
2. Mathematical methods for Physics and Engineering; K. F Riley, M. P Hobson, S.J Bence,
Cambridge University Press.
3. Graduate Mathematical Physics (With Mathematica Supplement); J J Kelly, Willey-VCH
Verlag GmbH and Co. KGaA.
4. Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris,
Elsevier.
5. Ordinary and Partial Differential equations; M. D Raisinghania, S. Chand and
Company Ltd.
6. Complex Variables; M R Spiegel, S Lipschutz, J J Schiller and D Spellman, Schaum's
Outline
Series, McGraw Hill Education.
7. Complex variables Demystified (A self teaching guide); D McMahan, McGraw Hill
Education..
8. Probability and Statistics; M R Spiegel, J J Schiller and R A Srinivasan, Schaum's
Outline Series, McGraw Hill Education.

Four Year Undergraduate Programme in Physics

Semester - V

Paper Name: Atomic and Molecular Physics-I

Paper Code: PHY0500104

Total number of lectures: 60 (45 L+ 15 T)

Total credits: 4 (Theory 3 +Tutorial 1)

Total Marks: 100 (60 (Th) +40 (Int))

Course Outcomes:

- CO1:** Explain the Bohr model and Sommerfeld's relativistic atom model, and fine structure of hydrogen atom lines and the limitations of both models.
- CO2:** Apply the concept of orbital magnetic dipole moment, Bohr magneton, and gyromagnetic ratio to explain the spin-orbit interaction and coupling schemes such as L-S and j-j coupling.
- CO3:** Analyze the Stern-Gerlach experiment and its conclusions, and interpret the results in the context of space quantization and electron spin.
- CO4:** Illustrate the principles of X-ray diffraction, the characteristic X-ray spectra, and the Compton effect, and describe their significance in atomic and molecular physics.
- CO5:** Outline the quantum theory of the Raman effect, its characteristics, and the complementary relationship between Raman and infrared spectra.

Contents:

Unit-I: Atom Model (15 L + 5 T)

The Bohr model of the hydrogen-like atom, Sommerfeld Relativistic Atom Model: Elliptical orbits, explanation of fine structure of H alpha line in Balmer series of hydrogen atom. Limitation of Sommerfeld atom model.

Orbital magnetic dipole moment: Bohr Magnetron, Gyromagnetic Ratio, Larmor precession, Space Quantization, Electron Spin, quantum numbers associated with vector atom model, spin-orbit interaction, Coupling Schemes: L-S Coupling and j-j Coupling, Spectroscopic term and their notation, Stern-Gerlach experiment and its conclusion.

Normal and Anomalous Zeeman Effect.

Paschen Back and Stark Effect (Qualitative Discussion only).

Unit-II: X-rays (6 L + 2T)

Ionizing Power, X-ray Diffraction, Bragg's Law, X-ray Spectra: Continuous and characteristic X-rays Mosley's law, Compton effect.

Unit-III: Multi electron atoms (7 L + 3 T)

Hund's rule, Periodic table: Pauli's exclusion principle, explanation of the periodic classification of the elements, Building up or Aufbau Principle, Broad features of Alkali atom (Na etc.) spectra and its explanation

Unit-IV: Molecular Spectra (11 L + 4 T)

Rotational Energy levels, Selection Rules and Pure Rotational Spectra of a diatomic Molecule. Vibrational Energy Levels, Selection Rules and Vibration Spectra of a diatomic Molecule. Rotation-Vibration Energy Levels, Selection Rules and Rotation-Vibration Spectra. Determination of Internuclear Distance.

Unit-V: Raman Effect (5 L + 2 T)

Quantum Theory of Raman Effect. Characteristics of Raman Lines. Stokes and Anti-Stokes Lines. Complementary Character of Raman and infrared Spectra.

Suggested Books:

1. Introduction to Atomic spectra, H. E. White, Tata McGraw Hill (1934)
2. Atomic and Molecular Spectra, Raj Kumar
3. Concepts of Modern Physics, Arthur Beiser (McGraw-Hill Book Company, 1987)
4. Atomic physics, J. B. Rajam & foreword by Louis De Broglie (S.Chand & Co., 2007)
5. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachin.
6. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash

Four Year Undergraduate Programme in Physics

Semester - V

Paper Name: Condensed Matter Physics

Paper Code: PHY0500204

Total number of lectures: 45

Total credits: 4 (Theory 3 +Laboratory 1)

Total Marks: 100 (45 (Th) +25 (Lab) +30 (Int))

Course Outcomes:

- CO1:** Describe the fundamental concepts of crystalline structure, lattice dynamics, nanomaterials, thin film and soft matter
- CO2:** Illustrate the dielectric, ferroelectric, magnetic properties in solids and basic conception superconductivity.
- CO3:** Apply the mathematical and theoretical concepts to analyse and solve problems related to crystalline solids, lattice dynamics.
- CO4:** Analyse theoretical models to interpret physical phenomena such Transport properties of material and magnetic behaviour.
- CO5:** Determine parameters related to crystallinity, electrical, magnetic and other properties of condensed matter.

Contents:

Unit-I: Crystal Structure and Bonding in solids (9 L)

Amorphous, crystalline and polycrystalline materials, lattice translation vectors, unit cell, types of crystal lattice, Bravais Lattice, Miller Indices, inter planer spacing. X-ray Diffraction (Basic Idea) Ionic, covalent, metallic, van-der-waal and hydrogen bondings, cohesive energy of ionic crystal, Madelung constant.

Unit-II: Elementary Lattice Dynamics (4 L)

Basic idea of lattice vibration and phonon. Dulong and Petit's Law. Einstein and Debye theories of specific heat of solids, T^3 law.

Unit-III: Dielectric and Ferroelectric Properties of Materials (10 L)

Polarization. local electric field at an Atom, depolarization field, electric susceptibility, polarizability. Clausius Mosotti equation, classical theory of electric polarizability, normal and anomalous dispersion, Cauchy and Sellmeier relations, Langevin-Debye equation.

Piezoelectric effect, pyroelectric effect, ferroelectric effect, electrostrictive effect, Curie-Weiss Law.

Unit-IV: Transport properties of materials (9 L)

Free electron theory of metals, electrical and thermal conductivity of metals, Wiedemann-Franz law, drawback of classical theory and modification with quantum theory,

preliminary idea of band theory, band gap, conductor, semiconductor (p and n type) and insulator, conductivity of semiconductor, mobility, measurement of conductivity (2-probe & 4-probe resistivity measurement method), Hall Effect (Qualitative idea).

Unit V: Nanophysics and soft matter (3 L)

Basic idea about nanomaterials, thin film physics and soft matter.

Unit VI: Magnetic Properties of Matter (7 L)

Dia, para, ferri, ferro and anti-ferromagnetic materials, classical Langevin Theory of dia and paramagnetism, Curie's law, Weiss' theory of ferromagnetic domains, discussion of B–H Curve, hysteresis and energy Loss.

Unit VII: Superconductivity (3 L)

Basic idea of superconductivity, critical temperature, critical magnetic field, Meissner effect. Type I and type II Super-conductors, isotope effect.

Laboratory (Credit =1)

A minimum of four experiments to be done.

1. Indexing of powder X-Ray diffraction data of cubic crystalline materials and determination of lattice parameters including inter planner spacing (XRD data needs to arrange by the department).
2. Measurement of susceptibility of a paramagnetic solution (Quinck's Tube Method).
3. To measure the magnetic susceptibility of solids.
4. To determine the Coupling Coefficient of a piezoelectric crystal.
5. To measure the Dielectric Constant of dielectric materials with frequency.
6. To study the P-E Hysteresis loop of a Ferroelectric Crystal.
7. To draw the B– H curve of Feusing Solenoid & determine energy loss from Hysteresis.
8. To measure the variation of resistivity of a semiconductor with temperature by four-probe method and to determine its band gap.
9. To determine the Hall coefficient of a semiconductor sample.

Suggested Books

1. *Introduction to Solid State Physics*, C Kittel
2. *Lattice Dynamics*, A K Ghatak and L S Kothari
3. *Solid State Physics*, A J Dekker.
4. *Introductory Solid State Physics*, H P Myers.
5. *Solid State Physics*, N W Ashcroft and N D Mermin
6. *Magnetism in solids*, D H Martin

7. *Physics of Magnetism*, S Chikazumi.
8. *Solid State Physics*, S O Pillai
9. *Introduction to Nanotechnology*, C. P. Poole, J. F. J. Owens

Four Year Undergraduate Programme in Physics

Semester - V

Paper Name: Heat & Thermodynamics

Paper Code: PHY0500304

Total number of lectures: 45

Total credits: 4 (Theory 3 +Laboratory 1)

Total Marks: 100 (45 (Th)+25 (Lab)+30 (Int))

Course Outcomes:

CO 1: Recognize the basic framework of kinetic theory of gases and thermodynamics.

CO 2: Interpret the behaviour of real gases.

CO 3: Apply the principles of thermodynamics to understand properties of thermodynamic systems.

CO 4: Analyze changes of entropy in reversible and irreversible processes.

CO 5: Estimate the thermodynamic potentials and their significance.

Contents:

Unit-I: Distribution of Velocities and Molecular Collisions (9 L)

Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required).

Mean Free Path. Collision Probability. Transport Phenomenon in Ideal Gases: (1) Viscosity, and (2) Thermal Conductivity. Brownian Motion (qualitative idea only).

Unit-II: Real Gases (8 L)

Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO₂ Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapor and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect, Joule-Kelvin coefficient for Ideal and Van der Waal Gases. Temperature of Inversion.

Unit-III: Principles of Thermodynamics (16 L)

Thermodynamic preliminaries: Extensive and intensive properties, Thermodynamic Variables, Thermodynamic Equilibrium, P-V indicator diagram. Work done in terms of P and V, Zeroth Law of Thermodynamics & Concept of Temperature, Internal energy and First Law of Thermodynamics, Applications of First Law: General Relation between C_p and C_v.

Reversible and Irreversible process with examples. Heat & work, state function, Conversion of heat into work and vice versa, Work Done during Isothermal and Adiabatic Processes, Heat Engines, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence, Carnot's Cycle, Carnotengine & efficiency. Refrigerator & coefficient of performance, Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Unit-IV: Entropy (6 L)

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

Unit-V: Thermodynamic Potentials and Thermodynamic Relations (6 L)

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy, Surface Films and Variation of Surface Tension with Temperature, Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of $C_p - C_v$, (3) TdS Equations, (4) Energy equations, (5) Change of Temperature during Adiabatic Process.

Laboratory (Credit =1)

A minimum of four experiments to be done.

1. To determine mechanical equivalent of heat, J, by Callender and Barne's constant flow method
2. To determine the mechanical equivalent of heat, J using calorimeter
3. To determine specific heat of a liquid using calorimeter
4. To determine the coefficient of the thermal conductivity of Cu by Searle's Apparatus.
5. To determine the coefficient of the thermal conductivity of an insulator by Lee and Charlton's disc method.
6. To determine the temperature coefficient of resistance by Platinum Resistance Thermometer (PRT).
7. To study the variation of the thermo-emf of a thermocouple with difference of temperature of its two junctions.
8. To determine the change of entropy of universe for an AC circuit consists of a thermally insulated resistor.
9. To calibrate a thermocouple to measure temperature in a specified range using (1) Null method, (2) Direct measurement using OPAMP and to determine neutral temperature.

Suggested Books

1. Heat and Thermodynamics, M. Zemansky, R. Dittman, McGraw-Hill Education, 2017.
2. A Treatise on Heat, Meghnad Saha and B.N. Srivastava, Indian Press, 1973.
3. Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics, S. C. Garg, R. M. Bansal and C. K. Ghosh, Tata McGraw Hill Education Pvt Ltd, 2013.
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, F. W. Sears & G. L. Salinger, Narosa Publishing House, 1998.
5. Thermal and Statistical Physics, R. B. Singh, New Academic Science, 2011.
6. Theory and Experiment on Thermal physics, PK. Chakrabarti, New Central Book Agency (P) Ltd, 2011.

**Four Year Undergraduate Programme in Physics
Semester - VI**

Paper Name: Nuclear and Particle Physics

Paper Code: PHY0600104

Total number of lectures: 60 (45 L +15 T)

Total credits: 4 (Theory 3 +Tutorial 1)

Total Marks: 100 (60 (Th)+40 (Int))

Course Outcomes:

- CO1:** On successful completion of the course, the students shall be able to discuss the basic structure and properties of a nucleus and their stability line.
- CO2:** Students can demonstrate the properties of strong nuclear force that keeps the nuclei bound and classify the radioactive decays, penetration and transformation.
- CO3:** Students get upgrade the knowledge on the construction and working principles of various particle accelerators, nuclear instrumentation and detector development.
- CO4:** Students can compare the merits and demerits of fusion and fission energy, their related technological development for generation of energy and control environment.
- CO5:** Students will enable to formulate the world of particle physics-types and interactions.

Contents:

Unit-I: Basic Properties of Nuclei (6 L +2 T)

Constituents of a nucleus: proton-electron hypothesis -Thompson atom model, failure of proton- electron hypothesis, discovery of neutrons, **Rutherford gold foil experiment** (qualitative) and atom model- mass, radius, volume, matter density of nuclei and their units. Binding energy, binding energy per nucleon, stability of a nucleus- neutron to proton ratio, stability line, stability limit against beta decays.

Unit-II: Radioactivity and Radioactive Laws (6 L +2 T)

Types of Radioactivity – alpha, beta, and gamma decay. Laws of radioactive decay, disintegration constant, half-life and mean life. Activity of a radioactive source, units of radioactivity.

Alpha decay: range, ionization and stopping power, range-energy relation, **Geiger-Nuttall law**, Fine structure of alpha energy spectrum.

Beta decays: types of beta decays, essential conditions of beta decays, beta ray spectra, end-point energy, Pauli's neutrino hypothesis. Gamma decay: origin of Gamma radiation, its property, attenuation of gamma radiation in matter.

Unit-III: Nuclear Reactions and Nuclear Models (9 L+3 T)

Types of nuclear reactions in terms of Q-value and energy, Direct reaction and compound nucleus formation, Cross section and flux measurements, LAB and COM frame of references and their conversion. Relation between threshold energy and Q-value, concept of Break up

threshold energy of loosely bound nuclei. Introduction to Liquid drop model. Semi-empirical mass formula, Magic numbers, Introduction to shell model and merits.

Unit-IV: Nuclear Instrumentation (9 L +3 T)

Detectors: Interaction of Radiation with Matter: Energy loss by a charged particle due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Interaction of photon with matter – Photoelectric effect, Compton effect, and Pair production, Gas filled detectors: Ionization chamber, proportional counter, and GM counter—construction and working principle Charged particle accelerators: Need of charged particle accelerators, Linear accelerator(LINAC) Construction and working principle.

Unit-V: Fission and Fusion (8 L +3 T)

Einstein's mass-energy equivalence principle and generation of nuclear energy. Nuclear Fission: Spontaneous and induced fission – definition and examples, Fission chain reactions and nuclear reactor: peaceful use of fission energy. Merits/Demerits Fusion and thermonuclear reactions: Energy production in stars (brief qualitative discussions).

Unit-VI: Elementary Particles (7 L +2 T)

Classification of elementary particles and their quantum numbers, conservation laws, Allowed and forbidden reactions, Types of interactions – strong, electro-magnetic and weak interactions.

Reference Books:

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999. 87
2. Nuclear Physics by SN Ghoshal, First edition, S. Chand Publication, 2010.
3. Introductory Nuclear Physics by KS Krane, Indian Adaption-SS Mallik& K. Kalita,3e, (Wiley),2022.
4. Introductory Nuclear Physics by KSKrane, Wiley India Pvt Ltd, 2008
5. NuclearPhysics: Principles and Applications by J Lilley,Wiley Publication,2006.
6. Radiation detection and measurement, GFKnoll, John Wiley & Sons,2010.
7. Schaum'sOutlineofModernPhysics,McGraw-Hill,1999.
8. Concept of Modern Physics by Arthur Beiser, Mc Graw HillEducation,2009.
9. Nuclear Radiation Detector by SS Kapoor and VS Ramamurthy, 1st edition, New Age international publisher.

**Four Year Undergraduate Programme in Physics
Semester - VI**

Paper Name: Digital Electronics

Paper Code: PHY0600204

Total number of lectures: 45

Total credits: 4 (Theory 3 +Laboratory 1)

Total Marks: 100 (45 (Th)+25 (Lab)+30 (Int))

Course Outcomes:

CO1: Recall the basics of digital electronics.

CO2: Discuss the working of logic gates.

CO3: Explain the theory related to Boolean algebra and K-Map.

CO4: Design different digital circuits like multi vibrators, flip flops and registers

CO5: Interpret the use of memory device.

Contents:

Unit-I: Integrated Circuits (qualitative treatment only) (5 L)

Active & Passive Components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. The scale of integration: SSI, MSI, LSI, and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital ICs.

Unit-II: Digital Circuits (10 L)

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal, and Hexadecimal numbers. AND, OR, and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. Binary Addition. Binary Subtraction using 2's Complement

Unit-III: Boolean Algebra (10 L)

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

Unit-IV: Arithmetic Circuits (5 L)

Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

Unit-V: Timers: IC 555 (4 L)

Block diagram and applications: Astable multivibrator and Monostable multivibrator.

Unit-VI: Sequential Circuits (6 L)

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.

Unit-VII: Shift Registers (5 L)

Serial-in-Serial-out. Serial-in-Parallel-out. Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

Laboratory (Credit =1)

A minimum of four experiments to be done.

1. To design a switch (NOT gate) using (i) a PNP transistor and (ii) an NPN 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 a logic circuit and design it using logic gate ICs.
5. To design a Half Adder and Full Adder
6. To design a 4-bit binary Adder.
7. To design Half Subtractor and Full Subtractor
8. To design Adder using Full Adder IC.
9. To design Subtractor using Full Adder IC.
10. To design an astable multivibrator of given specifications using 555 Timer.
11. To design a monostable multivibrator of given specifications using 555 Timer.
12. To build a D flip-flop circuit using NAND gates.
13. To build a JK flip-flop circuit using NAND gates.
14. To build JK Master-slave flip-flop using flip-flop ICs.
15. To make a 4-bit Serial Shift Register using D-type/JK Flip-Flop ICs.
16. To make a 4-bit Parallel Shift Register using D-type/JK Flip-Flop ICs.
17. To build SR flip-flop circuit using NAND gates

Suggested 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 Electronics G. K. Kharate ,2010, Oxford University Press
5. Digital Systems: Principles & Applications, R. J. Tocci, N. S. Widmer, 2001, PHI Learning
6. Logic circuit design, Shimon P. Vingron, 2012, Springer.
7. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
8. Digital Electronics, S. K. Mandal, 2010, 1st edition, McGraw Hill
9. Electronics Fundamentals and Applications, D. Chattopadhyay and P. C. Rakshit, 17th Ed, 2023, New Age International Publishers

**Four Year Undergraduate Programme in Physics
Semester - VI**

Paper Name: Astronomy & Astrophysics-I

Paper Code: PHY0600304

Total number of lectures: 60 (45 L+ 15T)

Total credits: 4 (Theory 3 +Tutorial 1)

Total Marks: 100 (60 (Th)+40 (Int))

Course Outcomes:

CO1: Recognise the basic concepts of physics required for Astronomy and Astrophysics

CO2: Interpret the results of basic observations in Astronomy

CO3: Implement laws of physics to understand stellar structure and evolution

CO4: Integrate the concepts to understand formation of solar system and galaxies.

CO5: Test the applicability of basic Astronomy concepts in learning origin and evolution of large scale structure of the universe.

Contents:

Unit-I: Fundamentals of Astronomy (8 L +3 T)

Basic components of the universe – stars, planets and galaxies; celestial sphere and celestial coordinates system - altitude-azimuth (Alt-Az) and right ascension-declination (RA-DEC); Introduction to constellations through sky observation and Stellarium; concept of time – universal time, solar and mean solar time, sidereal time, local sidereal time, Julian day; flux and luminosity of celestial objects; stellar magnitude scale – apparent and absolute magnitude; measurement of stellar distances – trigonometric parallax; introduction to HIPPARCOS and GAIA.

Unit-II: Astronomical techniques (8 L +3 T)

Telescopes –size and light gathering power; resolving power; different types of optical telescopes (reflecting and refracting); space telescopes; concept of virtual observatory; virtual observatory tools in Astronomy – SIMBAD, Aladin; SDSS, AAVSO, Sky-View; introduction to photometry; CCD –an introduction; spectroscopy and polarimetry.

Unit-III: Stellar Astrophysics (12 L +4 T)

Star formation from interstellar medium (introduction only); stellar properties- mass, luminosity, radius and effective surface temperature and their relationships; variable stars- cepheids; star clusters – open and globular, their ages (introduction only).

Gravity and thermodynamics – hydrostatic equilibrium of stars; virial theorem; internal temperature and pressure of stars; spectral classification – HR diagram; stellar evolution- idea of nucleosynthesis in main sequence phase- pp and CNO cycle; evolution of Sun-like stars off the main sequence -red giants and white dwarfs- Chandrasekhar mass limit (introduction only); evolution of massive stars – neutron stars and black holes (introduction only).

Unit-IV: The solar system (5 L +2 T)

The Sun and its structure; Formation of the solar system – Kant-Laplace nebular hypothesis; asteroid belt and meteorites; Distances and atmospheres of planets; Pluto and dwarf planets; comets – Kuiper belt and Oort cloud; extra-solar planets – transit method of detection (introduction only).

Unit-V: Galaxies and cosmology (12 L+ +3 T)

The Milky Way and its structure; classification of galaxies –Hubble’s tuning fork diagram; types of galaxies – spirals, elliptical and lenticular and their differences.

Large scale structure of the universe – galaxies, clusters, superclusters, filaments, walls and voids; Cosmological Principle; Hubble’s law; Newtonian cosmology and derivation of Friedman equation; closed and oscillating universe, flat and open universe; the Hot Big Bang model; Cosmic Microwave Background (CMB); steady state universe (introduction only); flat rotation curves in galaxies and evidence of dark matter; dark energy (introduction only).

Suggested text books:

- (1) Astrophysics for physicists, A. Rai Choudhuri, Cambridge University Press.
- (2) An introduction to the theory of stellar structure and evolution, D. Prialnik, Cambridge University Press.
- (3) Astrophysics- Stars and galaxies, K. D. Abhyankar, Tata McGraw Hill Pub.
- (4) Textbook of Astronomy and Astrophysics with elements of cosmology, V. B. Bhatia, Narosa Pub.
- (5) Astronomy Methods - A Physical Approach to Astronomical Observations, Hale Bradt, Cambridge University Press.
- (6) Introduction to Astrophysics, H.L. Duorah and K. Duorah, Mani Manik Prakash (Guwahati).
- (7) Astrophysical Techniques, C R Kitchin, Institute of Physics Publishing, Bristol and Philadelphia
- (8) Spherical Astronomy, W. M. Smart, Cambridge University Press.
- (9) Handbook of CCD Astronomy, S. B. Howell, Cambridge University Press
- (10) Astronomical Photometry, Arne A. Henden and Ronald H. Kaitchuck, Willmann-Bell, Inc., P.O. Box 35025, Richmond, Virginia 23235

Suggested reference books

1. The physical universe – An introduction to Astronomy, F. H. Shu, University of Science Books.
 2. The structure of the universe, J.V. Narlikar, Oxford University Press.
 3. Introduction to cosmology, B. Ryden, Cambridge University Press.
-

Four Year Undergraduate Programme in Physics

Semester - VI

Paper Name: Statistical Mechanics-I

Paper Code: PHY0600404

Total number of lectures: 60 (45 L+ 15 T)

Total credits: 4 (Theory 3 +Tutorial 1)

Total Marks: 100 (60 (Th) +40 (Int))

Course Outcomes:

CO 1: Recall classical and quantum theories of radiation.

CO2: Discuss basic concepts of statistical mechanics.

CO 3: Apply ensemble theories and evaluate partition functions.

CO 4: Differentiate classical and quantum statistics.

CO5: Interpret Bose-Einstein and Fermi-Dirac statistics and understand characteristic differences of quantum systems.

Contents:

Unit-I: Classical Statistics (12 L+ 4 T)

Microstate and macrostate, distributions of particles in compartments, principle of equal a priori probability. Phase space, volume of phase space. Elementary concept of ensembles, Types of ensembles. Ergodic hypothesis. Entropy and thermodynamic probability, Stirling's approximation, Maxwell-Boltzmann distribution function, Partition functions. Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) — Applications to specific heat and its limitations. Thermodynamic parameters (internal energy, entropy, free energy, enthalpy) using partition functions.

Unit-II: Classical and Quantum Theory of Radiation (12 L+ 4 T)

Properties of thermal radiation. Blackbody radiation. Spectral distribution of blackbody radiation, Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation pressure (for Normal and diffused case). Wien's Displacement law. Wien's Distribution Law. Saha's ionization formula. Rayleigh-Jean's Law (with proof). Ultraviolet catastrophe.

Need of quantum statistics. Planck's quantum postulates. Planck's law of blackbody radiation: Experimental verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's blackbody radiation formula.

Unit-III: Bose-Einstein Statistics (12 L+ 4 T)

Bose-Einstein (BE) distribution, Pressure of an ideal Bose gas, Bose Einstein Condensation (qualitative description only), Properties of liquid Helium (qualitative discussion only), Radiation as a photon gas and derivation of Planck's blackbody radiation formula, Thermodynamic functions of photon gas – energy, pressure, heat capacity, entropy, and free energy.

Unit-IV: Fermi-Dirac Statistics (12 L+ 3 T)

Fermi-Dirac (FD) distribution, FD function and Fermi Energy, Degenerate Fermi gas, strongly degenerate case (qualitative discussion only), Thermodynamic functions - energy and pressure of a completely degenerate Fermi gas, Heat capacity at low temperature, Free electron gas in metals and electronic specific heat, Relativistic Fermi gas, thermodynamics of white dwarf star (qualitative discussion only).

Reference Books:

1. Statistical Mechanics, R K Pathria and P D Beale, Elsevier Science, 2021.
2. Statistical Physics, F. Reif, McGraw-Hill Education India, 2008.
3. Statistical and Thermal Physics, S. Lokanathan and R. S. Gambhir, PHI Learning, 1991.
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, Springer, 2009.
5. An Introduction to Statistical Mechanics & Thermodynamics, R. H. Swendsen, Oxford University Press, 2012.
6. A Primer of Statistical Mechanics, R. B. Singh, New Age International Publishers, 2006.

**Four Year Undergraduate Programme in Physics
Semester - VII**

Paper Name: Mathematical Physics-II

Paper Code: PHY4700104MJ

Total number of contact hours: 60 (45 L + 15 T)

Total credits: 4 (Theory 3 + Tutorial 1)

Total Marks: 100 (60 (Th) + 40 (Int))

Course Outcomes:

After completing this course, students will be able to:

CO 1: Explain linear vector spaces, inner products, operators and matrix methods.

CO 2: Apply tensor algebra and tensor calculus to problems in physics.

CO 3: Use Laplace and Fourier transforms to solve differential equations.

CO 4: Analyze finite groups, representations and character tables.

CO 5: Relate Lie groups and Lie algebras to symmetry problems in physics.

Contents:

Unit-I: Linear Vector Spaces and Matrix Methods (11 L + 4 T)

Linear vector spaces: definition, properties, linear independence, basis and dimension; inner and outer products, Hilbert space, orthogonality and Gram-Schmidt orthogonalization. Linear operators and their algebra; projection operators, completeness relation and matrix representation. Parametrization of special matrices; change of basis, diagonalization, spectral theorem for Hermitian matrices, Cayley-Hamilton theorem and singular value decomposition. Direct product/tensor product of two vector spaces ($V \otimes W$).

Unit-II: Tensor Algebra (5 L + 1 T)

Introduction to tensors; transformation of coordinates; Einstein's summation convention. Contravariant, covariant and mixed tensors. Symmetric and antisymmetric tensors, Kronecker delta, Levi-Civita tensor. Quotient law of tensors. Rules of combination of tensors: addition, subtraction, outer multiplication, contraction and inner multiplication.

Unit-III: Tensor Calculus (11 L + 4 T)

Differentiable manifolds and coordinate systems; transformation of coordinates: Galilean and Lorentz transformations in tensorial language; tangent vectors and gradients; metric tensor in different curved spaces. Four-vectors and physical examples from special relativity and electrodynamics; Christoffel symbols, covariant derivatives and parallel transport; geodesics. Idea of curvature.

Unit-IV: Integral Transformations (7 L + 2 T)

Laplace transform and inverse Laplace transform. Fourier transform. Shifting theorem and convolution. Solution of differential equations with the help of Laplace and Fourier transform.

Unit-V: Group Theory (11 L + 4 T)

Group axioms and examples; finite groups, cyclic groups Z_n , permutation groups S_2 , S_3 , and $D_3 \simeq S_3$, multiplication tables, subgroups, cosets and conjugacy classes. Direct and semi-direct products. Representations of groups; reducible and irreducible representations, block diagonalisation, Schur's lemma, characters and character tables; decomposition of reducible and product representations. Lie groups: $SU(2)$ and $SO(3)$; related generators and Casimir operators; Lie algebra.

Reference Books:

1. Mathematical methods for physicists, Arfken and Weber.
2. Mathematical Physics, P. K. Chattopadhyay.
3. Matrices and tensors in Physics, A. W. Joshi.
4. Mathematical methods in the Physical Sciences, Mary L. Boas.
5. Mathematics for physicists, P. Dennery and A. Krzywicki.
6. Mathematical Physics: with applications, problems and solutions, V. Balakrishnan.
7. Introduction to Relativity, J. V. Narlikar.
8. Mathematical Physics, A. G. Ghatak, I. C. Goyal and S. J. Chua.
9. Group Theory: A Physicist's Survey.
10. Group Theory for Physicists with Application, P. Ramadevi and V. Dubey.
11. Symmetries in Quantum Mechanics, M. Chaichian and R. Hagedorn.

**Four Year Undergraduate Programme in Physics
Semester - VII**

Paper Name: Quantum Mechanics-II

Paper Code: PHY4700204MJ

Total number of lectures: 60 (45 L + 15 T)

Total credits: 4 (Theory 3 +Tutorial 1)

Total Marks: 100 (60 (Th)+40 (Int))

Course outcomes:

- CO 1:** Interpret and apply the concepts of superposition of states, Bra and Ket vectors algebra, and orthonormal conditions in quantum mechanics.
- CO 2:** Apply perturbation theory, variational method, and time-dependent perturbation theory to analyze quantum systems and evaluate their limitations.
- CO 3:** Illustrate space and time translations, rotational invariance, and angular momentum operators.
- CO 4:** Analyze combinations of wave functions, exchange degeneracy, and quantum statistics for systems of identical particles.
- CO 5:** Examine and conclude the act of measurement and quantum harmonic oscillator.

Contents:

Unit-I: Matrix formulation of quantum mechanics (16 L + 6 T)

Quantum states and linear algebra, superposition of states, act of measurement, Bra-Ket vectors and applications, orthonormal and completeness conditions, Hermitian operators, simultaneous eigen states, expectation values, change of basis, linear harmonic oscillator. Heisenberg's uncertainty principle in matrix mechanics. Heisenberg's equation of motion and physical equivalence of Schrödinger & Heisenberg picture.

Unit-II: Identical particles (6 L + 2 T)

Indistinguishability, combinations of wave functions for a system of particles, symmetric and antisymmetric wave functions, spin-statistics connection, evolution of quantum statistics, exchange symmetry and exchange degeneracy.

Unit-III: Symmetry, invariance principle, and conservation (9 L + 3 T)

Space and time translations, rotational invariance under infinitesimal and finite rotations. Angular momentum operators, ladder operators, addition of angular momenta - Clebsch-Gordan coefficients, Wigner-Eckart theorem, time evolution.

Unit-IV: Approximation methods in quantum mechanics (14 L + 4 T)

Time independent perturbation theory, Stark and Zeeman effects, variational method and its applications, WKB approximation, time dependent perturbation theory, transition to continuum states, Fermi's Golden rule, adiabatic and sudden approximation.

Reference Books:

1. Quantum Mechanics, L I Schiff
2. Quantum Mechanics, S N Biswas
3. Quantum Mechanics, A K Ghatak and S Lokanathan
4. Introductory Quantum Mechanics, R L Liboff
5. Principles of Quantum Mechanics, R Shankar
6. Quantum Mechanics: concepts and applications, N Zettili

**Four Year Undergraduate Programme in Physics
Semester - VII**

Paper Name: Electronics

Paper Code: PHY4700304MJ

Total number of lectures: 60 (45 L + 15 T)

Total credits: 4 (Theory 3 +Tutorial 1)

Total Marks: 100 (60 (Th)+40 (Int))

Course Outcomes:

CO1: Recall the basic principle of electronics.

CO2: Explain the working of different electronic circuits and components.

CO3: Operate on the various electronic circuits and components.

CO4: Relate different components of electronic systems.

CO5: Summarize the use of electronic circuits for various applications.

Contents:

Unit-I: Electronic Devices and applications (7 L)

Carrier concentrations in semiconductors; direct and indirect band gap semiconductors, Band structure of p-n junction; Homo and hetero-junction devices; SCR. UJT. JFET. MOSFET. CMOS. Tunnel diode. GUNN diode.

Application of UJT: Relaxation oscillator, Application of SCR: Saw tooth generator. Application of JFET: Amplifier, AC equivalent circuit, and voltage gain. Application of CMOS: as NOR gate and NAND gate operation.

Unit-II: Optoelectronics (6 L)

Working principle of LED. Relation between forbidden energy gap and emitted wavelength. Power and quantum efficiency of LED.

Photodetector materials. The basic principle for optical detection. P-N junction photodiode and its disadvantage. Noise in optical devices. . Photo Transistor, its structure, and operation.

Unit-III: Filters (6 L)

Ideal filters, Low pass. High Pass, Band pass and band reject filters. Cut off frequency and roll-off rate for different orders, Use of OPAMP as filters, Design of 1st order Low Pass, High Pass, Band Pass, and Band Reject filter.

Unit-VI: Data Processing Circuits (5 L)

The basic idea of Multiplexers. De-multiplexers. Decoders. Encoders.

Unit-VII: Counters (4 bits) (4 L)

Ring Counter. Asynchronous counters. Decade Counter. Synchronous Counter.

Unit-VIII: Conversion of Analog and Digital Voltages (3 L)

Digital to analog conversion (DAC): Resistive network (Weighted and R – 2R Ladder).

Analog to digital conversion (ADC): Basic block diagram. Nyquist Rate. Counter type ADC. Successive approximation method. Accuracy and Resolution of ADC.

Unit-IX: Intel 8085 Microprocessor Architecture (7 L)

Microprocessor as a CPU, organization of Microprocessor based systems, 8085 Architecture, operations and pin diagram, 8085 programming model: Registers, Flags, Program counter and Stack pointer, Bus organization, Microprocessor communication and Bus Timing, Stack and Subroutine. Introduction to Assembly language (basic concept)

Unit-X: Introduction to Communication System (4 L)

Introduction to analog and digital communication. Amplitude and Frequency Modulation, modulation index, bandwidth and frequency spectrum (Basic Concept), Advantage and Disadvantage of Analog and Digital Communication. Representation of Digital Communication using ASK, FSK, PSK (Basic Concept)

Unit XI: Nanoelectronics (3 L)

Introduction to nanoelectronics (basic concept, Introduction to nanolithography process with an overview of photolithography (Basic Concept).

Reference Books:

1. Electronic Devices and Circuit Theory, R L Boylestad
2. Electronic Devices and Circuits, T Bogart, J S Beasley and G Rico
3. Electronic Devices, T L Floyd
4. Modern Digital Electronics, R P Jain
5. Optoelectronics and Fiber Optics Communication, C K Sarkar and D C Sarkar
6. OPAMPS and Linear Integrated Circuits, Ramakant A Gayakwad.
7. Operational Amplifier and Linear Integrated Circuits, R F Coughlin and F F Driscoll.
8. Modern Digital and Analog Communication Systems, B P Lathi.
9. Electronic Communication System, George Kennedy. 6. Communication Systems, Simon Haykin
10. Microprocessor Architecture Programming & applications with 8085, 2002, R. S. Goankar, Prentice Hall.

**Four Year Undergraduate Programme in Physics
Semester - VII**

Paper Name: Research Methodology

Paper Code: PHY4700404MJ

Total number of lectures: 60 (45 L + 15 T)

Total credits: 4 (Theory 3 +Tutorial 1)

Total Marks: 100 (60 (Th)+40 (Int))

Course Outcomes

CO 1: Develop a research plan, and formulate the objectives

CO 2: Use internet, and carry out a survey of literature

CO 3: Examine data by statistical approach

CO 4: Present the findings as a research paper, or a powerpoint/poster presentation

CO 5: Infer on plagiarism

Contents:

Unit-I: Introduction to Research. (15 L + 5 T)

Research: meaning, characteristics and types. Paper, article, workshop, seminar, conference and symposium; Defining each major concept in operational terms: an overall description of approach, clearly stating any assumptions; Details of techniques. Expected outcome. Methodology to be adopted, planning of experiments for achieving the aims and objectives. Reproducibility of research work. Literature survey of the previous works. Review of an article in the relevant field and preparation of a short report. Use of internet networks in research activities in searching material, paper downloading. Sources, acquisition and interpretation of data. Quantitative and qualitative data. Graphical representation and mapping of data.

Unit-II: Statistical analysis (15 L + 5 T)

Error analysis and propagation. Types of data, Representation of data: tabular and diagrammatic methods, Inference from data: averages and higher moments. Scatter plots: Correlation tests. Conditional probability, Bayes theorem, probability distributions, likelihood estimation. Data-fitting (regression), types of errors, hypothesis testing and confidence limits.

Unit-III: Research Presentation and Academic Integrity (15 L + 5 T)

Steps of scientific writing: flow method, organisation of material and style. Types of report: research paper, thesis/dissertation. Drawing figures, graphs, tables, footnotes, references etc. in a research paper. Preparation in power point for oral, and for poster presentation in scientific seminar. Development of communication skill in presentation of scientific seminars: eye to eye contact, facing to audience, question & answer sessions etc. Plagiarism: meaning, why and how to avoid it, self-plagiarism.

Suggested Books

1. Research Methodology: Methods and Techniques, by C.R. Kothari and Gaurav Garg, New Age International Publishers.
2. Research Methodology and Techniques in Physics, by Anil Kumar Singh, Anmol Publishers.
3. Research Methods: The Basics, by Nicholas Walliman, Taylor and Francis.
4. Data Reduction and Error Analysis for Physical Sciences, by Philip R. Bevington and D. Keith Robinson, McGraw-Hill Education.
5. The Ethics of Teaching and Scientific Research, Edited by Sidney Hook, Paul Kurtz and Miro Todorovich, Prometheus Books, 1977.

Four Year Undergraduate Programme in Physics
Semester - VII
Paper Name: Atomic and Molecular Physics-I (Minor)
Paper Code: PHY4700704MN
Total number of lectures: 60 (45 L+ 15 T)
Total credits: 4 (Theory 3 +Tutorial 1)
Total Marks: 100 (60 (Th) +40 (Int))

Course Outcomes:

- CO1:** Explain the Bohr model and Sommerfeld's relativistic atom model, and fine structure of hydrogen atom lines and the limitations of both models.
- CO2:** Apply the concept of orbital magnetic dipole moment, Bohr magneton, and gyromagnetic ratio to explain the spin-orbit interaction and coupling schemes such as L-S and j-j coupling.
- CO3:** Analyze the Stern-Gerlach experiment and its conclusions, and interpret the results in the context of space quantization and electron spin.
- CO4:** Illustrate the principles of X-ray diffraction, the characteristic X-ray spectra, and the Compton effect, and describe their significance in atomic and molecular physics.
- CO5:** Outline the quantum theory of the Raman effect, its characteristics, and the complementary relationship between Raman and infrared spectra.

Contents:

Unit-I: Atom Model (15 L + 5 T)

The Bohr model of the hydrogen-like atom, Sommerfeld Relativistic Atom Model: Elliptical orbits, explanation of fine structure of H alpha line in Balmer series of hydrogen atom. Limitation of Sommerfeld atom model.

Orbital magnetic dipole moment: Bohr Magnetron, Gyromagnetic Ratio, Larmor precession, Space Quantization, Electron Spin, quantum numbers associated with vector atom model, spin-orbit interaction, Coupling Schemes: L-S Coupling and j-j Coupling, Spectroscopic term and their notation, Stern-Gerlach experiment and its conclusion.

Normal and Anomalous Zeeman Effect.

Paschen Back and Stark Effect (Qualitative Discussion only).

Unit-II: X-rays (6 L + 2T)

Ionizing Power, X-ray Diffraction, Bragg's Law, X-ray Spectra: Continuous and characteristic X-rays Mosley's law, Compton effect.

Unit-III: Multi electron atoms (7 L + 3 T)

Hund's rule, Periodic table: Pauli's exclusion principle, explanation of the periodic classification of the elements, Building up or Aufbau Principle, Broad features of Alkali atom (Na etc.) spectra and its explanation

Unit-IV: Molecular Spectra (11 L + 4 T)

Rotational Energy levels, Selection Rules and Pure Rotational Spectra of a diatomic Molecule. Vibrational Energy Levels, Selection Rules and Vibration Spectra of a diatomic Molecule. Rotation-Vibration Energy Levels, Selection Rules and Rotation-Vibration Spectra. Determination of Internuclear Distance.

Unit-V: Raman Effect (5 L + 2 T)

Quantum Theory of Raman Effect. Characteristics of Raman Lines. Stokes and Anti-Stokes Lines. Complimentary Character of Raman and infrared Spectra.

Suggested Books:

1. Introduction to Atomic spectra, H. E. White, Tata McGraw Hill (1934)
2. Atomic and Molecular Spectra, Raj Kumar
3. Concepts of Modern Physics, Arthur Beiser (McGraw-Hill Book Company, 1987)
4. Atomic physics, J. B. Rajam & foreword by Louis De Broglie (S.Chand & Co., 2007)
5. Physics of Atoms and Molecules, B. H. Bransden and C. J. Joachin.
6. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash

**Four Year Undergraduate Programme in Physics
Semester - VIII**

Paper Name: Atomic and Molecular Physics-II

Paper Code: PHY4800104MJ

Total number of lectures: 60 (45 L+ 15 T)

Total credits: 4 (Theory 3 +Tutorial 1)

Total Marks: 100 (60 (Th)+40 (Int))

Course Outcomes:

- CO1:** Explain the Pauli exclusion principle, LS and j-j coupling, and the basics of spectral terms in atomic physics.
- CO2:** Use selection rules to analyze rotational, vibrational, and Raman spectra of diatomic molecules, demonstrating comprehension of molecular physics.
- CO 3:** Outline the basic elements of a laser system, and distinguish between temporal and spatial coherence properties of the laser.
- CO 4:** Apply Einstein's relations to explain light amplification and determine the threshold condition for oscillation, and obtain the necessary condition for achieving population inversion in two-, three- and four-level laser systems.
- CO 5:** Understand laser cavity modes, explain ammonia maser and different lasers with applications in holography and optical communication.

Contents:

Unit-I: Atomic Physics (15 L + 5 T)

Pauli exclusion principle: spectral terms from two equivalent electrons, Vector model for three or more valence electrons and spectral terms, branching rule, Landé interval rule, LS and j-j coupling schemes, energy levels, selection rules, spectra of oxygen, nitrogen and manganese atoms; Zeeman effect, Paschen- Back effect, Stark effect in hydrogen, hyperfine structure, determination of nuclear spin and nuclear g-factors, Breadth of spectrum lines: natural broadening, Doppler broadening, collision broadening, and Stark broadening.

Unit-II: Molecular Physics (15 L + 5 T)

IR spectra - rotation, vibration and rotation-vibration spectra of diatomic molecules, selection rules, determination of rotational constants. Electronic spectra: Born-Oppenheimer approximation, vibrational structure of electronic transition, progressions and sequences of vibrational bands, Intensity distribution, Franck Condon principle. Raman spectra: Classical theory of Raman effect, Vibrational Raman spectrum, selection rules, Stokes and anti-Stokes lines, Rotational Raman spectrum, selection rule.

Unit-III: Lasers (15 L + 5 T)

Basic elements of a laser, properties of laser light; spontaneous and stimulated emission: Einstein coefficients, light amplification, population inversion and threshold condition for laser oscillations, optical resonator modes of a rectangular cavity, rate equations: two-level,

three-level and four-level systems; ammonia maser, ruby laser, He-Ne laser, CO₂ lasers, laser applications: holography and optical communication.

Reference Books:

1. *Introduction to Atomic Spectra*, H E White.
2. *Physics of Atoms and Molecules*, B H Bransden and C J Joachain
3. *Fundamentals of Molecular Spectroscopy*, C N Banwell and E M McCash.
4. *Spectra of Diatomic Molecules (Vol. 1)*, G Herzberg.
5. *Lasers and Nonlinear Optics*, B B Laud.
6. *Lasers : Theory and Applications*, K Thyagarajan and A K Ghatak

**Four Year Undergraduate Programme in Physics
Semester - VIII**

Paper Name: Condensed Matter Physics-II

Paper Code: PHY4800204MJ

Total number of lectures: 60 (45 L+ 15 T)

Total credits: 4 (Theory 3 +Tutorial 1)

Total Marks: 100 (60 (Th) +40 (Int))

Course Outcomes:

- CO 1:** Describe the fundamental concepts of matter in condensed state, crystalline structure and lattice dynamics
- CO 2:** Illustrate the structural, electrical, and magnetic properties such as band theory in solids, superconductivity, dielectric and ferroelectric Properties
- CO 3:** Apply the mathematical and theoretical concepts to analyse and solve problems related to crystalline solids, lattice dynamics, semiconductor, and magnetic properties.
- CO 4:** Analyse theoretical models to interpret physical phenomena such as phonons, dielectric relaxation, energy band structures, and magnetic behaviour.
- CO 5:** Determine parameters related to crystallinity, electrical, magnetic and other properties of condensed matter.

Contents:

Unit-I: Crystalline Solids (8 L+ 3 T)

Symmetry operations, point groups and space groups, X-ray diffraction, Bragg's law, reciprocal lattice, atomic scattering factor, geometrical structure factor, quasicrystals, defects in crystals.

Unit-II: Lattice Dynamics (5 L+ 1 T)

Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Dispersion relations in mono atomic and diatomic linear lattices, normal modes.

Unit-III: Dielectric and Ferroelectric Properties (6 L+ 2 T)

Complex dielectric constant and dielectric loss, dielectric relaxation, Debye equations, optical phenomena, dipole theory of ferroelectric domains, P-E hysteresis loop, structural phase transition, anti-ferroelectricity.

Unit-IV: Energy Bands in Solids (6 L+ 2 T)

Bloch function, Kronig-Penney model, Brillouin zones, effective mass of charge carriers, tight binding approximation and Wigner-Seitz method.

Unit-V: Nanophysics and Soft Matter (3 L+ 1 T)

Understanding of nanomaterials (0-D, 1-D, 2-D & 3-D) and their synthesis procedures. Basic characterization techniques of nanomaterials: XRD (X-Ray Diffraction), UV-VIS-NIR spectrophotometry, TEM (Transmission Electron Microscopy), SEM (Scanning Electron Microscopy), AFM (Atomic Force Microscopy). Brief idea about thin film technology (synthesis and characterization), Soft Matter.

Unit-VI: Semiconductors (6 L+ 2 T)

Number density of carriers in intrinsic and extrinsic semiconductors, expression for Fermi levels, recombination processes, photoconductivity, Hall effect in metals and semiconductors.

Unit-VII: Magnetic Properties (7 L+ 2 T)

Quantum theory of diamagnetism and paramagnetism, diamagnetic and paramagnetic susceptibilities of free electrons, molecular field theory of ferromagnetism, anti-ferromagnetism and ferrimagnetism, anisotropic energy, Electron paramagnetic resonance and nuclear magnetic resonance.

Unit-VIII: Superconductivity (5 L+ 1 T)

Thermodynamics of superconducting state, London equations, penetration depth, coherence length, idea of BCS theory.

Reference Books:

1. *Introduction to Solid State Physics*, C Kittel
2. *Lattice Dynamics*, A K Ghatak and L S Kothari
3. *Solid State Physics*, A J Dekker.
4. *Introductory Solid State Physics*, H P Myers.
5. *Solid State Physics*, N W Ashcroft and N D Mermin
6. *Magnetism in solids*, D H Martin
7. *Physics of Magnetism*, S Chikazumi.
8. *Solid State Physics*, S O Pillai
9. *Introduction to Nanotechnology*, C. P. Poole, J. F. J. Owens

Four Year Undergraduate Programme in Physics

Semester - VIII

Paper Name: Nuclear Physics-II

Paper Code: PHY4800304MJ

Total number of lectures: 60 (45 T+ 15 L)

Total credits: 4 (Theory 3 +Tutorial 1)

Total Marks: 100 (60 (Th)+40 (Int))

Course Objective: The objective of this course is to impart the basic understanding of the nucleus, different representation of nuclear models, nuclear reactions and other sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches of Physics and society. The course will focus on the developments of problem based skills at the nuclear scale.

Course outcomes:

CO1: The course describes the structure of nuclei and interactions between the nucleons and nuclei.

CO2: Discuss about the construction and working principles of accelerators and detectors

CO3: Learners would be able to distinguish strong nuclear interaction with other fundamental interactions of the nature and learn about nuclear instrumentation.

Contents:

Unit-I: Nuclear Structure: Models of Nuclei (12 L+ 4 T)

Liquid drop model (LDM): Evidences in support of LDM, Establishment of Semi-empirical mass formula, its applications in – (i) estimating the energy released in fission of heavy nuclei, (ii) in predicting the most stable member of an isobaric family against beta decay. Success and Limitations of LDM.

Shell Model: Evidences in favour of Shell model, Labelling of Shell model states to obtain shell closure at magic numbers, Spin and parity of various nuclei in the light of Single Particle Shell Model.

Unit-II: Forces Between Nucleons (9 L+ 3 T)

Characteristics of nucleon-nucleon interactions with examples, Neutron-proton bound system: Deuteron – its binding energy, spin and parity, magnetic dipole moment, electric quadrupole moment, Quantum mechanical approach to estimate deuteron potential.

Unit-III: Nuclear Reactions (12 L+ 4 T)

Concept of two body nuclear reactions for fixed target experiment – concept of flux, fluence, pnA, solid angle, and cross-section.

Classification of nuclear reactions, kinematics of two body nuclear reaction – LAB and CM coordinate system, Rutherford alpha particle scattering experiment – corrections for extended object, QM and relativistic effects. Concept compound nuclear reaction – Bohr compound nucleus hypothesis, Ghosal experiment.

Unit-IV: Accelerators and Radiation Detectors (12 L+ 4 T)

Accelerators: Limitations of liner accelerators, Concept of Cyclic accelerator: Cyclotron – its working principle and construction, limitation of Cyclotron, Synchrotron (only concept).

Detectors: Photon detectors – Scintillator detectors – Working principle of NaI(Tl) scintillator detector, PMT and its construction and working principle, Ge(Li) detector (introduction only).

Charged particle detector: Si Surface Barrier detector (SSB) – construction and working principles, Resistive Plate Detector (RPC) – an introduction, SSNTD.

Reference Books:

1. Introductory Nuclear Physics – Kenneth S Krane
2. Introduction to Nuclear Reactions – G R Satchler
3. Nuclear Physics: Theory and Experiment – R R Roy and B P Nigam
4. Radiation Detection and Measurement – G F Knoll
5. Techniques for Nuclear and Particle Physics Experiments - W R Leo

**Four Year Undergraduate Programme in Physics
Semester - VIII**

Paper Name: Seminar based on Laboratory work

Paper Code: PHY4800404MJ

Total number of lectures:

Total credits: 4

Total Marks: 100

Course Outcomes:

CO 1: Describe the laboratory methods for the experiments as listed in the content.

CO 2: Demonstrate use of OPAMPs and ICs in electronic circuits.

CO 3: Analyze methods to evaluate properties of metals, semiconductors and magnetic materials.

CO 4: Measure physical quantities using optical methods.

CO 5: Determine the characteristics of GM counter and study nuclear processes.

List of Practicals:

A. Electronics:

1. Draw the V-I characteristic curve of a tunnel diode.
2. Draw the V-I characteristic curve of a Gunn diode.
3. To study transfer and output characteristics of an n-channel Junction field effect Transistor (JFET) in Common-source configuration.
4. Determine the value of the Planck Constant using LED.
5. To design a digital-to-analog converter (DAC) of given specifications.
6. To study the analog-to-digital converter (ADC) IC.
7. Design high pass filter using OPAMPs. Estimate the cutoff frequency and roll-off rate.
8. Design low pass filter using OPAMPs. Estimate the cutoff frequency and roll-off rate.
9. Design bandpass filters using OPAMPs
10. Design band reject filters using OPAMPs
11. Design and study the gain of an Instrumentation Amplifier.
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. Write the following programs using 8085 Microprocessor
 - Addition and subtraction of numbers using direct addressing mode
 - Addition and subtraction of numbers using indirect addressing mode
 - Multiplication by repeated addition
 - Division by repeated subtraction
 - Handling of 16-bit Numbers

B. Optics:

1. Determine the track spacing and pattern of the tracks of a CD.
2. Determine the Young's modulus of the material of a rod by Newton's ring method.
3. Verify the Malus Law

4. Verify the Heisenberg's uncertainty principle using He-Ne laser
5. Determine wavelength of a given light source using the Michelson interferometer
6. Determination of the grating element of the double slit by observing interference and using lamp and scale method
7. To determine the thickness of a given mica sheet by using Jamin's interferometer
8. To find out the separation between the sodium D-lines using a grating and hence to determine the minimum number of lines required in the given grating to resolve sodium D-lines in the first and second order

C. Electricity:

3. Measurement of resistivity of a semiconductor sample using Van der PAUW method
4. Perform the Hall Effect experiment by recording the Hall voltage at different sample currents under different magnetic field strengths. Plot suitable graph and hence determine Hall coefficient and carrier concentration. Identify conductivity type of the semiconductor.
5. To study the dispersion relation for the monoatomic and diatomic lattice
6. Determine the coercivity, retentivity, and saturation magnetization of a given ferromagnetic specimen using B-H loop curve.
7. Determination of Hall Coefficient of a semiconductor sample using Van der PAUW Experiment

D. Nuclear Physics:

1. Determine the plateau of the given GM counter and its percentage slope. Hence, study the statistical fluctuation (with beta source).
2. Study the absorption of beta rays passing through different thickness of Al and determine the linear absorption coefficient.
3. To determine the beta particle range and maximum energy by half thickness method
4. To verify inverse square law for gamma rays using GM tube

Four Year Undergraduate Programme in Physics
Semester - VIII
Paper Name: Astronomy & Astrophysics-I (Minor)
Paper Code: PHY4800604MN
Total number of lectures: 60 (45 L+ 15T)
Total credits: 4 (Theory 3 +Tutorial 1)
Total Marks: 100 (60 (Th) +40 (Int))

Course Outcomes:

- CO1:** Recognise the basic concepts of physics required for Astronomy and Astrophysics
CO2: Interpret the results of basic observations in Astronomy
CO3: Implement laws of physics to understand stellar structure and evolution
CO4: Integrate the concepts to understand formation of solar system and galaxies.
CO5: Test the applicability of basic Astronomy concepts in learning origin and evolution of large scale structure of the universe.

Contents:

Unit-I: Fundamentals of Astronomy (8 L +3 T)

Basic components of the universe – stars, planets and galaxies; celestial sphere and celestial coordinates system - altitude-azimuth (Alt-Az) and right ascension-declination (RA-DEC); Introduction to constellations through sky observation and Stellarium; concept of time – universal time, solar and mean solar time, sidereal time, local sidereal time, Julian day; flux and luminosity of celestial objects; stellar magnitude scale – apparent and absolute magnitude; measurement of stellar distances – trigonometric parallax; introduction to HIPPARCOS and GAIA.

Unit-II: Astronomical techniques (8 L +3 T)

Telescopes –size and light gathering power; resolving power; different types of optical telescopes (reflecting and refracting); space telescopes; concept of virtual observatory; virtual observatory tools in Astronomy – SIMBAD, Aladin; SDSS, AAVSO, Sky-View; introduction to photometry; CCD –an introduction; spectroscopy and polarimetry.

Unit-III: Stellar Astrophysics (12 L +4 T)

Star formation from interstellar medium (introduction only); stellar properties- mass, luminosity, radius and effective surface temperature and their relationships; variable stars- cepheids; star clusters – open and globular, their ages (introduction only).

Gravity and thermodynamics – hydrostatic equilibrium of stars; virial theorem; internal temperature and pressure of stars; spectral classification – HR diagram; stellar evolution- idea of nucleosynthesis in main sequence phase- pp and CNO cycle; evolution of Sun-like stars off the main sequence -red giants and white dwarfs- Chandrasekhar mass limit (introduction only); evolution of massive stars – neutron stars and black holes (introduction only).

Unit-IV: The solar system (5 L +2 T)

The Sun and its structure; Formation of the solar system – Kant-Laplace nebular hypothesis; asteroid belt and meteorites; Distances and atmospheres of planets; Pluto and dwarf planets; comets – Kuiper belt and Oort cloud; extra-solar planets – transit method of detection (introduction only).

Unit-V: Galaxies and cosmology (12 L+ +3 T)

The Milky Way and its structure; classification of galaxies –Hubble’s tuning fork diagram; types of galaxies – spirals, elliptical and lenticular and their differences.

Large scale structure of the universe – galaxies, clusters, superclusters, filaments, walls and voids; Cosmological Principle; Hubble’s law; Newtonian cosmology and derivation of Friedman equation; closed and oscillating universe, flat and open universe; the Hot Big Bang model; Cosmic Microwave Background (CMB); steady state universe (introduction only); flat rotation curves in galaxies and evidence of dark matter; dark energy (introduction only).

Suggested text books:

1. Astrophysics for physicists, A. Rai Choudhuri, Cambridge University Press.
2. An introduction to the theory of stellar structure and evolution, D. Prialnik, Cambridge University Press.
3. Astrophysics- Stars and galaxies, K. D. Abhyankar, Tata McGraw Hill Pub.
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V. B. Bhatia, Narosa Pub.
5. Astronomy Methods - A Physical Approach to Astronomical Observations, Hale Bradt, Cambridge University Press.
6. Introduction to Astrophysics, H.L. Duorah and K. Duorah, Mani Manik Prakash (Guwahati).
7. Astrophysical Techniques, C R Kitchin, Institute of Physics Publishing, Bristol and Philadelphia
8. Spherical Astronomy, W. M. Smart, Cambridge University Press.
9. Handbook of CCD Astronomy, S. B. Howell, Cambridge University Press
10. Astronomical Photometry, Arne A. Henden and Ronald H. Kaitchuck, Willmann-Bell, Inc., P.O. Box 35025, Richmond, Virginia 23235

Suggested reference books

1. The physical universe – An introduction to Astronomy, F. H. Shu, University of Science Books.
2. The structure of the universe, J.V. Narlikar, Oxford University Press.
3. Introduction to cosmology, B. Ryden, Cambridge University Press.

Four Year Undergraduate Programme in Physics

Semester VIII

Paper: Dissertation

Paper Code: PHY4800712

Credits 12

Course Outcomes:

- CO1:** Demonstrate a comprehensive understanding of the chosen research area through an extensive review of relevant scientific literature and contemporary developments.
- CO2:** Identify and analyze a research problem, formulate research objectives, and establish appropriate hypotheses or research questions.
- CO3:** Apply theoretical concepts, experimental techniques, computational tools, or analytical methods relevant to the selected research problem.
- CO4:** Critically evaluate existing research findings, methodologies, and experimental/computational approaches reported in the literature.
- CO5:** Design a suitable research methodology, experimental setup, computational framework, or analytical procedure for addressing the identified research problem.
- CO6:** Prepare and present a detailed project proposal, literature survey report, and preliminary findings in a scientifically structured format following ethical research practices.