Course Structure

of

Physics Department

B.Sc. Physics

(w.e.f. 2023-24 as per NEP and CBCS)

DEPARTMENT OF PHYSICS

Institute of Applied Sciences & Humanities

B. Sc. Physics I Year, First Semester

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHC 0001	Mathematical Physics & Newtonian Mechanics	4	0	0	4
2.	BCHE0011	Chemistry-I (Principles of Chemical Sciences)	4	0	0	4
3.	BMAE0101	Maths- I (Algebra & Calculus)	4	0	0	4
4.		Multidisciplinary –I	3	0	0	3
5.	BELA0003	AEC-I (Language Skill I)	2	0	0	2
6.		VAC-I	2	0	0	2
7.	BPHC 0801	Mechanical Properties and Matter	0	0	4	2
		TOTAL CREDITS				**21**

B. Sc. Physics I Year, Second Semester

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHC0002	Thermal Physics & Semiconductor Devices	4	0	0	4
2.	BPHC0021	Elements of Nanomaterials	4	0	0	4
3.	BMAS0505	Maths- II (Statistical and Numerical Methods)	4	0	0	4
4.		Skills Enhancement-I	2	0	0	3
5.	BELA0004	AEC-II (Language Skill II)	2	0	0	2
6.		VAC-II	2	0	0	2
7.	BPHC0802	Thermal Properties of Matter & Electronics Circuits	0	0	4	2
		TOTAL CREDITS				**21**

B.Sc. Physics II Year, Third Semester

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHC 0003	Electromagnetic Theory & Modern Optics	4	0	0	4
2.	BMAE0103	Ordinary and Partial Differential Equations	4	0	0	4
3.	BCHE0014	Chemistry-II (Chemical Dynamics & Energetics)	4	0	0	4
4.	BPHC 0022	Waves & Oscillations	4	0	0	4
5.		Multidisciplinary –II	3	0	0	3
6.		VAC-III	1	0	0	2
7.	BELA 0007	AEC-III (Technical Writing)	2	0	0	2
8.	BPHC 0803	Demonstrative Aspects of Electricity & Magnetism	0	0	4	2
		TOTAL CREDITS				**25**

B.Sc. Physics II Year, Fourth Semester

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHC 0004	Perspective of Modern Physics & Basic Electronics	4	0	0	4
2.	BPHC 0023	Atomic and Molecular Physics	4	0	0	4
3.	BCHE 0013	Chemistry III (Solid State and Quantum Mechanics)	4	0	0	4
4.	BPHE 0006	Introduction to Quantum Computation	4	0	0	4
5.		Skills Enhancement-II	3	0	0	3
6.	BELA 0012	AEC-IV (Workplace Communication)	2	0	0	2
7.		VAC-IV	2	0	0	2
8.	BPHC 0804	Basic Electronics Instrumentation	0	0	4	2
		TOTAL CREDITS				**25**

B.Sc. Physics III Year, Fifth Semester

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHC 0005	Classical & Statistical Mechanics	4	0	0	4
2.	BPHC 0006	Quantum Mechanics & Spectroscopy	4	0	0	4
3.	BPHC 0024	Electronic Devices & Circuits	4	0	0	4
4.		Multidisciplinary -III	3	0	0	3
5.		VAC-V	1	0	0	1
6.	BPHC 0805	Demonstrative Aspects of Optics & Lasers	0	0	4	2
7.		Summer Internship				4
		TOTAL CREDITS				**22**

B.Sc. Physics III Year, Sixth Semester

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHC 0007	Solid State & Nuclear Physics	4	0	0	4
2.	BPHC 0008	Analog & Digital Principles & Applications	4	0	0	4
3.		Skills Enhancement-III	3	0	0	3
4.	BPHC 0025	Astronomy and Astrophysics	4	0	0	4
	BPHC 0026	Optoelectronics				
5.		Advance Mathematical Physics	4	0	0	4
6.		VAC-VI	1	0	0	1
7.	BPHC 0806	Analog & Digital Circuits	0	0	4	2
		TOTAL CREDITS				**22**

B.Sc. Physics(Hons/ By Research) IV Year: To be uploaded

B.Sc. Physics (Compulsory Courses)

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHC 0001	Mathematical Physics & Newtonian Mechanics	4	0	0	4
2.	BPHC0002	Thermal Physics & Semiconductor Devices	4	0	0	4
3.	BPHC 0003	Electromagnetic Theory & Modern Optics	4	0	0	4
4.	BPHC 0 004	Perspective of Modern Physics & Basic Electronics	4	0	0	4
5.	BPHC 0005	Classical & Statistical Mechanics	4	0	0	4
6.	BPHC 0006	Quantum Mechanics & Spectroscopy	4	0	0	4
7.	BPHC 0007	Solid State & Nuclear Physics	4	0	0	4
8.	BPHC 0008	Analog & Digital Principles & Applications	4	0	0	4
9.	BPHC 0801	Mechanical Properties and Matter	0	0	4	2
10.	BPHC0802	Thermal Properties of Matter & Electronics Circuits	0	0	4	2
11.	BPHC 0803	Demonstrative Aspects of Electricity & Magnetism	0	0	4	2
12.	BPHC 0804	Basic Electronics Instrumentation	0	0	4	2
13.	BPHC 0805	Demonstrative Aspects of Optics & Lasers	0	0	4	2
14.	BPHC 0806	Analog & Digital Circuits	0	0	4	2

B.Sc. Physics (Major Courses)

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHC 0021	Elements of Nanomaterials	4	0	0	4
2.	BPHC 0022	Waves & Oscillations	4	0	0	4
3.	BPHC 0023	Atomic and Molecular Physics	4	0	0	4
4.	BPHC 0024	Electronic Devices & Circuits	4	0	0	4
5.	BPHC 0025 BPHC 0026	Astronomy and Astrophysics Optoelectronics	4	0	0	4

B.Sc. Physics (Minors Courses)

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHE 0001	OPTICS	3	0	0	3
2.	BPHE 0002	FUNDAMENTALS OF WAVES AND OSCILLATIONS	3	0	0	3
3.	BPHE 0003	HEAT AND THERMODYNAMICS	4	0	0	4
4.	BPHE 0004	ATOMIC PHYSICS	4	0	0	4
5.	BPHE 0005	SOLAR AND ASTROPHYSICS	4	0	0	4
6.	BPHE 0801	OPTICS LAB	0	0	2	1
7.	BPHE 0802	WAVES & OSCILLATIONS LAB	0	0	2	1

B.Sc. Physics (Multidisciplinary Courses)

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHO 0001	SCIENCE AND TECHNOLOGY OF HYDROGEN ENERGY	3	0	0	3
2.	BPHO 0002	SCIENCE AND TECHNOLOGY OF SOLAR ENERGY	3	0	0	3
3.	BPHO 0003	SATELLITE COMMUNICATION AND REMOTE SENSING	3	0	0	3

B.Sc. Physics (Skill Enhancement Courses)

S. NO.	CODE	SUBJECT	TEACHING SCHEME			CREDITS
			LECTURE	TUTORIALS	PRACTICALS	
1.	BPHO 0011	RADIATION SAFETY	3	0	0	3
2.	BPHO 0012	APPLIED OPTICS	3	0	0	3
3.	BPHO 0013	RENEWABLE ENERGY AND ENERGY HARVESTING	3	0	0	3
4.	BPHO 0014	BASIC INSTRUMENTATION SKILLS	3	0	0	3
5.	BPHO 0015	ELECTRICAL CIRCUITS AND NETWORK SKILLS	3	0	0	3

BPHC 0001: MATHEMATICAL PHYSICS & NEWTONIAN MECHANICS

OBJECTIVES: During this course, the students will learn about basic vector algebra, vector calculus, coordinate systems and tensors. In addition, students will learn dynamics of rigid body, physics of rotational systems and waves. At the end of this course, they will be able to apply these concepts to various physical problems.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Vector Algebra:** Coordinate rotation, reflection and inversion as the basis for defining scalars, vectors, pseudoscalars and pseudo-vectors (include physical examples). Component form in 2D and 3D. Geometrical and physical interpretation of addition, subtraction, dot product, wedge product, cross product and triple product of vectors. Position, separation and displacement vectors. **Vector Calculus:** Geometrical and physical interpretation of vector differentiation, Gradient, Divergence and Curl and their significance. Vector integration, Line, Surface (flux) and Volume integrals of vector fields. Gradient theorem, Gauss-divergence theorem, Stoke-curl theorem, Greens theorem and Helmholtz theorem (statement only). Introduction to Dirac delta function. **Dynamics of a System of Particles:** Dynamics of a system of particles, centre of mass motion, and conservation laws, their deductions and applications. Rotating frames of reference, general derivation of origin of pseudo forces (Euler, Coriolis & centrifugal) in rotating frame, and effects of Coriolis force. **Dynamics of a Rigid Body:** Angular momentum, Torque, Rotational energy and the inertia tensor. Rotational inertia for simple bodies (ring, disk, rod, solid and hollow sphere, solid and hollow cylinder, rectangular lamina). The combined translational and rotational motion of a rigid body on horizontal and inclined planes. Elasticity, relations between elastic constants, bending of beam and torsion of cylinder.	24
II	**Coordinate Systems:** 2D & 3D Cartesian, Spherical and Cylindrical coordinate systems, basis vectors, transformation equations. Expressions for displacement vector, arc length, area element, volume element, gradient, divergence and curl in different coordinate systems. Components of velocity and acceleration in different coordinate systems. Examples of non-inertial coordinate system and pseudo-acceleration. **Introduction to Tensors:** Principle of invariance of physical laws w.r.t. different coordinate systems as the basis for defining tensors. Contravariant, covariant & mixed tensors and their ranks, 4-vectors. Index notation and summation convention. Symmetric and skewsymmetric tensors. Invariant tensors, Kronecker delta and Epsilon (Levi Civita) tensors. Examples and applications of tensors in physics. **Motion of Planets & Satellites:** Two particle central force problem, reduced mass, relative and centre of mass motion. Newton's law of gravitation, gravitational field and gravitational potential. Kepler's laws of planetary motion and their deductions. Motions of geo-synchronous & geo-stationary satellites and basic idea of Global Positioning System (GPS).	24

	Wave Motion: Differential equation of simple harmonic motion and its solution, use of complex notation, damped and forced oscillations, Quality factor. Composition of simple harmonic motion, Lissajous figures. Differential equation of wave motion. Plane progressive waves in fluid media, reflection of waves and phase change, pressure and energy distribution. Principle of superposition of waves, stationary waves, phase and group velocity. Acoustic waves and their propagation. Applications of acoustic waves.	

Reference Books/ Text Books

1. Murray Spiegel, Seymour Lipschutz, Dennis Spellman, "Schaum's Outline Series: Vector Analysis", McGrawHill, 2017, 2e2.
2. A.W. Joshi, "Matrices and Tensors in Physics", New Age International Private Limited, 1995, 3e
3. Charles Kittel, Walter D. Knight, Malvin A. Ruderman, Carl A. Helmholz, Burton J. Moyer, "Mechanics (In SIUnits): Berkeley Physics Course Vol 1", McGraw Hill, 2017, 2e2
4. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 1", Pearson Education Limited, 20123.
5. Hugh D. Young and Roger A. Freedman, "Sears & Zemansky's University Physics with Modern Physics",Pearson Education Limited, 2017, 14e4.
6. D.S. Mathur, P.S. Hemne, "Mechanics", S. Chand Publishing, 1981, 3e

Course Outcomes:

CO1: To understand about vector quantities and algebra of vector addition and multiplication.

CO2: To have a clear idea of vector differentiation and integration of vector valued functions, their physical significance, and the key associated theorems.

CO3: To learn the concepts inertial frame of reference, rotating frame of reference, various Newton laws and their limitations, work, energy, momentum, different forces, and related conservation laws.

CO4: To describe about the mechanical properties of matter like rigidity, rotational inertia, moment of inertia, rotational motion, and elasticity.

CO5: To differentiate between types of co-ordinate systems, their transformation equations and its application to vector calculus.

CO6: To explain about the basics of tensors, types of tensors, and show that they have mastered the fundamental techniques for using tensor analysis to describe physical systems.

CO7: To understand the mechanics involved with stars and planets.

CO8: To understand, correlate and apply the mechanics in their daily life.

BPHC 0002: THERMAL PHYSICS AND SEMICONDUCTOR DEVICES

OBJECTIVES: Gain the basic knowledge and principles of heat and thermodynamics and analyze different thermodynamical systems based on these principles. To make the students familiar with basic components of electronic devices like semiconductors, diodes transistors, filters and their applications.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**0th & 1st Law of Thermodynamics:** State functions and terminology of thermodynamics. Zeroth law and temperature. First law, internal energy, heat and work done. Work done in various thermodynamical processes. Enthalpy, relation between C_P and C_V. Carnot's engine, efficiency and Carnot's theorem. **2nd & 3rd Law of Thermodynamics:** Different statements of second law, Clausius inequality, entropy and its physical significance. Entropy changes in various thermodynamical processes. Third law of thermodynamics and unattainability of absolute zero. Thermodynamical potentials, Maxwell's relations, conditions for feasibility of a process and equilibrium of a system. Clausius- Clapeyron equation, Joule-Thompson effect. Liquification of gases: Hydrogen and Helium. **DC & AC Circuits:** Growth and decay of currents in RL circuit. Charging and discharging of capacitor in RC, LC and RCL circuits. Network Analysis - Superposition, Reciprocity, Thevenin's and Norton's theorems. AC Bridges - measurement of inductance (Maxwell's, Owen's and Anderson's bridges) and measurement of capacitance (Schering's, Wein's and de Sauty's bridges). **Semiconductors & Diodes:** P and N type semiconductors, qualitative idea of Fermi level. Formation of depletion layer in PN junction diode, field & potential at the depletion layer. Qualitative idea of current flow mechanism in forward & reverse biased diode. Diode fabrication. PN junction diode and its characteristics, static and dynamic resistance. Principle, structure, characteristics and applications of Zener, Tunnel, Light Emitting, Point Contact and Photo diodes. Half and Full wave rectifiers, calculation of ripple factor, rectification efficiency and voltage regulation. Basic idea about filter circuits and voltage regulated power supply. Clippers and clampers.	24
II	**Kinetic Theory of Gases:** Derivation of Maxwell's law of distribution of velocities and its experimental verification. Degrees of freedom, law of equipartition of energy (no derivation) and its application to specific heat of gases (mono, di and poly atomic). **Theory of Radiation:** Blackbody radiation, spectral distribution, concept of energy density and pressure of radiation. Derivation of Planck's law, deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan Boltzmann law and Wien's displacement law from Planck's law. **Transistors:** Bipolar Junction PNP and NPN transistors. Study of different configurations of transistor in active, cutoff & saturation regions; characteristics; current, voltage & power gains; transistor currents & relations between them. DC Load Line analysis and Q-point stabilisation. Variation of Q point with temperature. **Electronic Instrumentation:** Multimeter: Principles of measurement of dc voltage, dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. Cathode Ray Oscilloscope: Block diagram of basic CRO. Construction of CRT, electron gun, electrostatic focusing and acceleration (no mathematical treatment). Front panel controls,	24

	special features of dual trace CRO, specifications of a CRO and their significance. Applications of CRO to study the waveform and measurement of voltage, current, frequency & phase difference.	

Reference Books/ Text Books

1. M.W. Zemansky, R. Dittman, "Heat and Thermodynamics", McGraw Hill, 1997, 7e2. F.W.
2. Sears, G.L. Salinger, "Thermodynamics, Kinetic theory & Statistical thermodynamics", Narosa PublishingHouse, 19983.
3. Enrico Fermi, "Thermodynamics", Dover Publications, 19564.
4. S. Garg, R. Bansal, C. Ghosh, "Thermal Physics", McGraw Hill, 2012, 2e5.
5. Meghnad Saha, B.N. Srivastava, "A Treatise on Heat", Indian Press, 1973, 5e
6. R.L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice-Hall of India Pvt. Ltd., 2015, 11e2
7. J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e3
8. B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e4.
9. J.D. Ryder, "Electronic Fundamentals and Applications", Prentice-Hall of India Private Limited, 1975, 5e5.
10. A. Sudhakar, S.S. Palli, "Circuits and Networks: Analysis and Synthesis", McGraw Hill, 2015, 5e6.
11. S.L. Gupta, V. Kumar, "Hand Book of Electronics", Pragati Prakashan, Meerut, 2016, 43e

Course Outcome

CO1- Explain the 0^{th} and 1^{st} law of thermodynamics as well as various thermodynamic parameters and processes
CO2- Understand the 2^{nd} and 3^{rd} law of thermodynamics, Carnot's engine, concept of entropy and Maxwell's relations
CO3- Analyze various forms of DC and AC circuits, networks, and different bridges
CO4- Understand basics of semiconductors, p-n junction diode, and its related devices
CO5- Explain the kinetic theory of gases and its application to specific heat of gases
CO6- Analyze the various laws of blackbody radiation
CO7- Interpret principle and characteristics of Bipolar Junction Transistor, analyze DC load line and Q point
CO8- Explain the physics behind multi-meter, as well as CRO and their uses

BPHC 0003: ELECTROMAGNETIC THEORY & MODERN OPTICS

OBJECTIVES: This course aims to provide a solid foundation in electromagnetic theory and optics, covering key concepts such as Maxwell's equations, wave propagation and boundary conditions, along with optical phenomena with interference, diffraction and polarization.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Electrostatics:** Electric force between two charges. General expression for Electric field in terms of *linear, surface* and volume charge densities, divergence & curl of Electric field, Expression for Electric potential. Gauss law and its *application to ring, hollow and solid sphere*. Electric field and potential due to electric dipole and quadrupole. Electric fields in matter, polarization **P**, displacement vector **D**, *relation between **D**, **E** and **P***. Electric susceptibility and permittivity. **Magnetostatics:** *Bio-Savart's law*, Magnetic force between two current elements, Lorentz force, Divergence and curl of Magnetic field, General expression for Magnetic potential in terms of volume current density, Ampere's circuital law and its applications. Study of magnetic dipole. Magnetic fields in matter, magnetisation, **H**, *relation between **B**, **H** and **M***, magnetic susceptibility and permeability. *Introduction to diamagnetic, paramagnetic and ferromagnetic materials.* **Interference:** Conditions for interference and spatial & temporal coherence. Division of Wavefront - Fresnel's Biprism and Lloyd's Mirror. Division of Amplitude - Parallel thin film, *color of films*, wedge shaped film and Newton's Ring experiment. Interferometer - Michelson. **Diffraction:** Distinction between interference and diffraction. Fresnel's and Fraunhofer's class of diffraction. Fresnel's Half Period Zones and Zone plate. Fraunhofer diffraction at a single slit, n slits and Diffracting Grating. Resolving Power of Optical Instruments - Rayleigh's criterion and resolving power of telescope, microscope & grating.	24
II	**Time Varying Electromagnetic Fields:** Faraday's laws (*in integral and differentials forms*) and Lenz's law. Displacement current, equation of continuity and Maxwell-Ampere's circuital law (*in integral and differentials forms*). Self and mutual induction (applications included). Derivation and physical significance of Maxwell's equations. Theory and working of moving coil ballistic galvanometer (applications included). **Electromagnetic Waves:** Electromagnetic energy density and Poynting vector. Plane electromagnetic waves in linear infinite dielectrics, homogeneous & inhomogeneous plane waves and dispersive & non-dispersive media. Reflection and refraction of homogeneous plane electromagnetic waves, law of reflection, Snell's law, Fresnel's formulae (only for normal incidence & optical frequencies) and Stoke's law. Applications: Shielding and Waveguides. **Polarisation:** Polarisation by dichronic crystals, birefringence, Nicol prism, retardation plates and compensator. Analysis of polarized light. Optical Rotation - Fresnel's explanation of optical rotation and Half Shade & Biquartz polarimeter.	24

	Lasers: Characteristics and uses of Lasers. Quantitative analysis of Spatial and Temporal coherence. Conditions for Laser action and Einstein's coefficients. Three and four level laser systems (qualitative discussion). *Ruby laser and He-Ne gas laser. Holography*.	

Reference Books/ Text Books

1. D.J. Griffiths, "Introduction to Electrodynamics", Prentice-Hall of India Private Limited, 2002, 3e
2. E.M. Purcell, "Electricity and Magnetism (In SI Units): Berkeley Physics Course Vol 2", McGraw Hill, 2017, 2e
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, The Feynman Lectures on Physics - Vol. 2, Pearson Education Limited, 2012
4. D.C. Tayal, "Electricity and Magnetism", Himalaya Publishing House Pvt. Ltd., 2019, 4e
5. Francis A. Jenkins, Harvey E. White, "Fundamentals of Optics", McGraw Hill, 2017, 4e
6. Samuel Tolansky, "An Introduction to Interferometry", John Wiley & Sons Inc., 1973, 2e
7. A. Ghatak, "Optics", McGraw Hill, 2017, 6e

Course Outcome

CO1. Better understanding of electrical and magnetic phenomenon in daily life.
CO2. To troubleshoot simple problems related to electrical devices.
CO3. Comprehend the powerful applications of ballistic galvanometer.
CO4. Study the fundamental physics behind reflection and refraction of light (electromagnetic waves).
CO5. Study the working and applications of Michelson and Fabry-Perot interferometers.
CO6. Recognize the difference between Fresnel's and Fraunhofer's class of diffraction.
CO7. Comprehend the use of polarimeters.
CO8. Study the characteristics and uses of lasers.

BPHC 0004: PERSPECTIVE OF MODERN PHYSICS & BASIC ELECTRONICS

OBJECTIVES: This course introduces the fundamental principles of Modern physics including special theory of relativity and quantum mechanics, alongside the principles and applications of electronic components like transistors and amplifiers. By integrating theoretical knowledge with practical circuit design and analysis.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Relativity-Experimental Background:** Structure of space & time, Inertial & non-inertial frames. Galilean transformations (GT). *Inadequacy of Galilean transformation equations. Invariance of momentum using GT equations*. Attempts to locate the Absolute Frame: Michelson-Morley experiment and significance of the null result. Einstein's postulates of special theory of relativity. **Relativity-Relativistic Kinematics:** Structure of space & time in Relativistic mechanics and derivation of Lorentz transformation equations. Consequences of Lorentz Transformation Equations: *Invariance of space time interval*, Transformation of Simultaneity; Transformation of Length (Length contraction); Transformation of Time (Time dilation); Transformation of Velocity (Relativistic velocity addition); Transformation of Mass (Variation of mass with velocity). Relation between Energy & Mass (Einstein's mass & energy relation) and Energy & Momentum. *Massless particle.* **Transistor Biasing:** Faithful amplification & need for biasing. Stability Factors and its calculation for transistor biasing circuits for CE configuration: Fixed Bias (Base Resistor Method), Emitter Bias (Fixed Bias with Emitter Resistor), Collector to Base Bias (Base Bias with Collector Feedback) &, Voltage Divider Bias. Discussion of Emitter-Follower configuration. **Amplifiers:** Classification of amplifiers based on Mode of operation (Class A, B and C), Stages (single & multi stage, cascade & cascade connections), Coupling methods (RC, Transformer, Direct & LC couplings), Nature of amplification (Voltage & Power amplification) and Frequency capabilities (AF, IF, RF & VF). Theory & working of RC coupled voltage amplifier (Uses of various resistors & capacitors, and Frequency response) and Transformer coupled power amplifier (calculation of Power, Effect of temperature, Use of heat sink & Power dissipation). Calculation of Amplifier Efficiency (power efficiency) for Class A Series-Fed, Class A Transformer Coupled, Class B Series-Fed and Class B Transformer Coupled amplifiers.	24
II	**Inadequacies of Classical Mechanics:** Particle Properties of Waves: *Physics* of Black Body radiation, Photoelectric effect, Compton effect and their explanations based on Max Planck's Quantum hypothesis. Wave Properties of Particles: Louis de Broglie's hypothesis of matter waves and their experimental verification by Davisson-Germer's experiment. **Introduction to Quantum Mechanics:** Matter Waves: Mathematical representation,	24

	Wavelength, Concept of Wave group, Group (particle) velocity, Phase (wave) velocity and relation between Group & Phase velocities. Wave Function: Functional form, Normalisation of wave function, Orthogonal & Orthonormal wave functions and Probabilistic interpretation of wave function based on Born Rule. *Conditions for acceptable wave functions.* **Feedback & Oscillator Circuits:** Feedback Circuits: Effects of positive and negative feedback. Voltage Series, Voltage Shunt, Current Series and Current Shunt feedback connection types and their uses for specific amplifiers. Estimation of Input Impedance, Output Impedance, Gain, Stability, Distortion, Noise and Band Width for Voltage Series negative feedback and their comparison between different negative feedback connection types. Oscillator Circuits: Use of positive feedback for oscillator operation. Barkhausen criterion for self sustained oscillations. Feedback factor and frequency of oscillation for RC Phase Shift oscillator and Wein Bridge oscillator. Qualitative discussion of Reactive Network feedback oscillators (Tuned oscillator circuits): Hartley & Colpitt oscillators. **Introduction to Fiber Optics:** Basics of Fiber Optics, step index fiber, graded index fiber, light propagation through an optical fiber, acceptance angle & numerical aperture, qualitative discussion of fiber losses and applications of optical fibers.	

Reference Books/ Text Books

1. A. Beiser, Shobhit Mahajan, “Concepts of Modern Physics: Special Indian Edition”, McGraw Hill, 2009
2. John R. Taylor, Chris D. Zafiratos, Michael A.Dubson, “Modern Physics for Scientists and Engineers”, Prentice-Hall of India Private Limited, 2003, 2e
3. R.A. Serway, C.J. Moses, and C.A. Moyer, “Modern Physics”, Cengage Learning India Pvt. Ltd, 2004,
4. R. Resnick, “Introduction to Special Relativity”, Wiley India Private Limited, 2007
5. R. Murugeshan, Kiruthiga Sivaprasath, “Modern Physics”, S. Chand Publishing, 2019, 18e
6. R.L. Boylestad, L. Nashelsky, “Electronic Devices and Circuit Theory”, Prentice-Hall of India Pvt. Ltd., 2015, 11e
7. J. Millman, C.C. Halkias, Satyabrata Jit, “Electronic Devices and Circuits”, McGraw Hill, 2015, 4e
8. B.G. Streetman, S.K. Banerjee, “Solid State Electronic Devices”, Pearson Education India, 2015, 7e
9. J.D. Ryder, “Electronic Fundamentals and Applications”, Prentice-Hall of India Private Limited, 1975
10. S.L. Gupta, V. Kumar, “Hand Book of Electronics”, Pragati Prakashan, Meerut, 2016, 43e

Course Outcomes:

1. Recognize the difference between the structure of space & time in Newtonian & Relativistic mechanics.
2. Understand the physical significance of consequences of Lorentz transformation equations.
3. Comprehend the wave-particle duality.
4. Develop an understanding of the foundational aspects of Quantum Mechanics.
5. Study the comparison between various biasing techniques.
6. Study the classification of amplifiers.
7. Comprehend the use of feedback and oscillators.
8. Comprehend the theory and working of optical fibers along with its applications.

BPHC 0005: CLASSICAL & STATISTICAL MECHANICS

OBJECTIVES: This course provides the ability to develop mathematical concepts of Lagrangian as well as Hamiltonian formulation to the classical systems. Emphasis will be on the application of Lagrangian and Hamiltonian formulation to the central forces. After the course, students will have the understanding about macroscopic and microscopic systems in statistical mechanics. The students will be able to differentiate between classical and quantum statistics and then apply the theory to different thermodynamical and statistical system of physical interest.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Constrained Motion:** Constraints - Definition, Classification and Examples. Degrees of Freedom and Configuration space. Constrained system, Forces of constraint and Constrained motion. Generalised coordinates, Transformation equations and Generalised notations & relations. Principle of Virtual work and D'Alembert's principle. **Lagrangian Formalism:** Lagrangian for conservative & non-conservative systems, Lagrange's equation of motion (no derivation), Comparison of Newtonian & Lagrangian formulations, Cyclic coordinates, and Conservation laws (with proofs and properties of kinetic energy function included). Simple examples based on Lagrangian formulation. **Macrostate & Microstate:** Macrostate, Microstate, Number of accessible microstates and Postulate of equal a priori. Phase space, Phase trajectory, Volume element in phase space, Quantisation of phase space and number of accessible microstates for free particle in 1D, free particle in 3D & harmonic oscillator in 1D. **Concept of Ensemble:** Problem with time average, concept of ensemble, postulate of ensemble average and Liouville's theorem (proof included). Micro Canonical, Canonical & Grand Canonical ensembles. Thermodynamic Probability, Postulate of Equilibrium and Boltzmann Entropy relation.	24
II	**Hamiltonian Formalism:** Phase space, Hamiltonian for conservative & non-conservative systems, Physical significance of Hamiltonian, Hamilton's equation of motion (no derivation), Comparison of Lagrangian & Hamiltonian formulations, Cyclic coordinates, and Construction of Hamiltonian from Lagrangian. Simple examples based on Hamiltonian formulation. **Central Force:** Definition and properties (with prove) of central force. Equation of motion and differential equation of orbit. Bound & unbound orbits, stable & non-stable orbits, closed & open orbits and Bertrand's theorem. Motion under inverse square law of force and derivation of Kepler's laws. Laplace-RungeLenz vector (Runge-Lenz vector) and its applications. **Distribution Laws:** Concept of Stirling approxiamation and derivation, Statistical Distribution Laws: Expressions for number of accessible microstates, probability & number of particles in ith state at equilibrium for Maxwell-Boltzmann, Bose-Einstein & FermiDirac statistics. Comparison of statistical distribution laws and their physical significance. Canonical Distribution Law: Boltzmann's Canonical Distribution Law, Boltzmann's Partition Function, Proof of Equipartition Theorem (Law of Equipartition of energy) and relation between Partition function and Thermodynamic potentials. **Applications of Statistical Distribution Laws:** Application of Bose-Einstein Distribution Law: Photons in a black body cavity and derivation of Planck's Distribution Law. Application of Fermi-Dirac Distribution Law: Free electrons in a metal, Definition of Fermi energy, Determination of Fermi energy at absolute zero, Kinetic energy of Fermi gas at absolute zero and concept of Density of States (Density of Orbitals).	24

Reference Books/ Text Books:

1. Herbert Goldstein, Charles P. Poole, John L. Safko, “Classical Mechanics”, Pearson Education, India, 2011, 3e.
2. N.C. Rana, P.S. Joag, “Classical Mechanics”, McGraw Hill, 2017.
3. R.G. Takwale, P.S. Puranik, “Introduction to Classical Mechanics”, McGraw Hill, 2017.
4. F. Reif, “Statistical Physics (In SI Units): Berkeley Physics Course Vol 5”, McGraw Hill, 2017, 1e.
5. B.B. Laud, “Fundamentals of Statistical Mechanics”, New Age International Private Limited, 2020, 2e.
6. B.K. Agarwal, M. Eisner, “Statistical Mechanics”, New Age International Private Limited, 2007, 2e.

Course Outcome:

CO1- Understand the concepts of generalized coordinates and D’Alembert’s principle.
CO2. Understand the Lagrangian dynamics and the importance of cyclic coordinates.
CO3. Comprehend the difference between Lagrangian and Hamiltonian dynamics.
CO4. Study the important features of central force and its application in Kepler’s problem.
CO5. Recognize the difference between macrostate and microstate.
CO6. Comprehend the concept of ensembles.
CO7. Understand the classical and quantum statistical distribution laws.
CO8. Study the applications of statistical distribution laws

BPHC 0006: QUANTUM MECHANICS & SPECTROSCOPY

OBJECTIVES: The course aims to develop a strong foundation in operator formalism, eigenvalues, and expectation values in quantum mechanics. Emphasis will be on understanding commutation relations, Hermitian operators and Applications of Schrodinger equation to various potential well problems as well as to hydrogen atom. Students will explore the vector atomic model, fine structure, and spectra of hydrogen, alkali, and alkaline elements. This course will develop an understanding about coupling schemes, spectroscopic transitions, characteristics of X-ray and vibrational-rotational spectra.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Operator Formalism**: Operators: Review of matrix algebra, definition of an operator, special operators, operator algebra and operators corresponding to various physical-dynamical variables. Commutators: Definition, commutator algebra and commutation relations among position, linear momentum & angular momentum and energy & time. Simple problems based on commutation relations. **Eigen & Expectation Values:** Eigen & Expectation Values: Eigen equation for an operator, eigen state (value) and eigen functions. Linear superposition of eigen functions and Non-degenerate & Degenerate eigen states. Expectation value pertaining to an operator and its physical interpretation. Hermitian Operators: Definition, properties and applications. Prove of the hermitian nature of various physical-dynamical operators. **Vector Atomic Model:** Inadequacies of Bohr and Bohr-Sommerfeld atomic models w.r.t. spectrum of Hydrogen atom (fine structure of H-alpha line). Modification due to finite mass of nucleus and Deuteron spectrum. Vector atomic model (Stern-Gerlach experiment included) and physical & geometrical interpretations of various quantum numbers for single & many valence electron systems. LS & jj couplings, spectroscopic notation for energy states, selection rules for transition of electrons and intensity rules for spectral lines. Fine structure of H-alpha line on the basis of vector atomic model. **Spectra of Alkali & Alkaline Elements:** Spectra of alkali elements: Screening constants for s, p, d & f orbitals; sharp, principle, diffuse & fundamental series; doublet structure of spectra and fine structure of Sodium D line. Spectra of alkaline elements: Singlet and triplet structure of spectra.	24
II	**Uncertainty Principle & Schrodinger Equation**: Uncertainty Principle: Commutativity & simultaneity (theorems with proofs). Non commutativity of operators as the basis for uncertainty principle and derivation of general form of uncertainty principle through Schwarz inequality. Uncertainty principle for various conjugate pairs of physicaldynamical parameters and its applications. Schrodinger Equation: Derivation of time independent & time dependent forms, Schrodinger equation as an eigen equation, Deviation & interpretation of equation of continuity in Schrodinger representation, and Equation of motion of an operator in Schrodinger representation. **Applications of Schrodinger Equation**: Application to 1D Problems: Infinite Square well potential (Particle in 1D box), Finite Square well potential, Potential step, Rectangular potential barrier and 1D Harmonic oscillator. Application to 3D Problems: Infinite Square well potential (Particle in a 3D box) and the Hydrogen atom (radial distribution function and radial probability included). (Direct solutions of Hermite, Associated Legendre and Associated Laguerre differential equations to be substituted). **X-Rays & X-Ray Spectra:** Nature & production, Continuous X-ray spectrum & Duane-Hunt's	24

	law, Characteristic X-ray spectrum & Mosley's law, Fine structure of Characteristic X-ray spectrum, and X-ray absorption spectrum. **Molecular Spectra:** Discrete set of energies of a molecule, electronic, vibrational and rotational energies. Quantisation of vibrational energies, transition rules and pure vibrational spectra. Quantisation of rotational energies, transition rules, pure rotational spectra and determination of inter nuclear distance. Rotational-Vibrational spectra; transition rules; fundamental band & hot band; O, P, Q, R, S branches.	

Reference Books/ Text Books:

1. D.J. Griffiths, "Introduction to Quantum Mechanics", Pearson Education, India, 2004, 2e.
2. E. Wichmann, "Quantum Physics (In SI Units): Berkeley Physics Course Vol 4", McGraw Hill, 2017.
3. Richard P. Feynman, Robert B. Leighton, Matthew Sands, "The Feynman Lectures on Physics - Vol. 3", Pearson Education Limited, 2012.
4. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e.
5. H.E. White, "Introduction to Atomic Spectra", McGraw Hill, 1934.
6. C.N. Banwell, E.M. McCash, "Fundamentals of Molecular Spectroscopy", McGraw Hill, 2017, 4e.
7. R Murugeshan, Kiruthiga Sivaprasath, "Modern Physics", S. Chand Publishing, 2019, 18e.
8. S.L. Gupta, V. Kumar, R.C. Sharma, "Elements of Spectroscopy", Pragati Prakashan, Meerut, 2015, 27e.

Course Outcome:

CO1- Understand the significance of operator formalism in Quantum mechanics.
CO2. Study the eigen and expectation value methods.
CO3. Understand the basis and interpretation of Uncertainty principle.
CO4. Develop the technique of solving Schrodinger equation for 1D and 3D problems.
CO5. Comprehend the success of Vector atomic model in the theory of Atomic spectra.
CO6. Study the different aspects of spectra of Group I & II elements.
CO7. Study the production and applications of X-rays.
CO8. Develop an understanding of the fundamental aspects of Molecular spectra.

BPHC 0007: SOLID STATE & NUCLEAR PHYSICS

OBJECTIVES: This course provides a thorough understanding of the fundamental concepts of crystal structures, diffraction techniques, and various bonding mechanisms in solids. The course develops foundational knowledge of solid-state physics, emphasizing band theory, free electron models, and structural analysis of materials. Additionally, the course covers nuclear properties, forces, and reactions, including radioactive decay mechanisms, nuclear models, and fission/fusion processes. Students will study the principles and applications of particle accelerators, detectors, and elementary particle classification, with an emphasis on conservation laws and the quark model.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Crystal Structure**: Lattice, Basis & Crystal structure. Lattice translation vectors, Primitive & non-primitive cells. Symmetry operations, Point group & Space group. 2D & 3D Bravais lattice. Parameters of cubic lattices. Lattice planes and Miller indices. Simple crystal structures - HCP & FCC, Diamond, Cubic Zinc Sulphide, Sodium Chloride, Cesium Chloride and Glasses. **Crystal Diffraction:** X-ray diffraction and Bragg's law. Experimental diffraction methods - Laue, Rotating crystal and Powder methods. Derivation of scattered wave amplitude. Reciprocal lattice, Reciprocal lattice vectors and relation between Direct & Reciprocal lattice. Diffraction conditions, Ewald's method and Brillouin zones. Reciprocal lattice to SC, BCC & FCC lattices. Atomic Form factor and Crystal Structure factor. **Nuclear Forces & Radioactive Decays**: General Properties of Nucleus: Mass, binding energy, radii, density, angular momentum, magnetic dipole moment vector and electric quadrupole moment tensor. Nuclear Forces: General characteristic of nuclear force and Deuteron ground state properties. Radioactive Decays: Nuclear stability, basic ideas about beta minus decay, beta plus decay, alpha decay, gamma decay & electron capture, fundamental laws of radioactive disintegration and radioactive series. **Nuclear Models & Nuclear Reactions**: Nuclear Models: Liquid drop model and Bethe-Weizsacker mass formula. Single particle shell model (the level scheme in the context of reproduction of magic numbers included). Nuclear Reactions: Bethe's notation, types of nuclear reaction, Conservation laws, Cross-section of nuclear reaction, Theory of nuclear fission (qualitative), Nuclear reactors and Nuclear fusion.	24
II	**Crystal Bindings**: Classification of Crystals on the Basis of Bonding - Ionic, Covalent, Metallic, van der Waals (Molecular) and Hydrogen bonded. Crystals of inert gases, Attractive interaction (van der WaalsLondon) & Repulsive interaction, Equilibrium lattice constant, Cohesive energy and Compressibility & Bulk modulus. Ionic crystals, Cohesive energy, Madelung energy and evaluation of Madelung constant. **Lattice Vibrations**: Lattice Vibrations: Lattice vibrations for linear mono & di atomic chains, Dispersion relations and Acoustical & Optical branches (qualitative treatment). Qualitative description of Phonons in solids. Lattice heat capacity, Dulong-Petit's law and Einstein's theory of lattice heat capacity. Free Electron Theory: Fermi energy, Density of states, Heat capacity of conduction electrons, Paramagnetic susceptibility of conduction electrons and Hall effect in metals. Band Theory: Origin of band theory, Qualitative idea of Bloch theorem, Kronig-Penney model, Effectice mass of an electron & Concept of Holes & Classification of	24

	solids on the basis of band theory. **Accelerators & Detectors**: Accelerators: Theory, working and applications of Van de Graaff accelerator, Cyclotron and Synchrotron. Detectors: Theory, working and applications of GM counter, Semiconductor detector, Scintillation counter and Wilson cloud chamber. **Elementary Particles**: Fundamental interactions & their mediating quanta. Concept of antiparticles. Classification of elementary particles based on intrinsic-spin, mass, interaction & lifetime. Families of Leptons, Mesons, Baryons & Baryon Resonances. Conservation laws for mass-energy, linear momentum, angular momentum, electric charge, baryonic charge, leptonic charge, isospin & strangeness. Concept of Quark model.	

Reference Books/ Text Books:

1. Charles Kittel, "Introduction to Solid State Physics", Wiley India Private Limited, 2012, 8e.
2. A.J. Dekker, "Solid State Physics", Macmillan India Limited, 1993.
3. R.K. Puri, V.K. Babbar, "Solid State Physics", S. Chand Publishing, 2015.
4. Kenneth S. Krane, "Introductory Nuclear Physics", Wiley India Private Limited, 2008.
5. Bernard L. Cohen, "Concepts of Nuclear Physics", McGraw Hill, 2017.
6. S.N. Ghoshal, "Nuclear Physics", S. Chand Publishing, 2019.

Course Outcome:

CO1- Understand the crystal geometry w.r.t. symmetry operations.
CO2. Comprehend the power of X-ray diffraction and the concept of reciprocal lattice.
CO3. Study various properties based on crystal bindings.
CO4. Recognize the importance of Free Electron & Band theories in understanding the crystal properties.
CO5. Study the salient features of nuclear forces & radioactive decays.
CO6. Understand the importance of nuclear models & nuclear reactions.
CO7. Comprehend the working and applications of nuclear accelerators and detectors.
CO8. Understand the classification and properties of basic building blocks of nature.

BPHC 0008: ANALOG & DIGITAL PRINCIPLES & APPLICATIONS

OBJECTIVES: This course provides an understanding of semiconductor physics, charge carrier dynamics, PN junctions, and the operation of semiconductor devices such as diodes, transistors (BJT, FET), MOSFETs, SCRs, and UJTs. It also covers number systems (binary, octal, decimal, hexadecimal), binary arithmetic, and various binary codes (BCD, Gray, ASCII). Students will gain an understanding of logic gates, Boolean algebra, and Karnaugh maps, followed by the design and analysis of combinational circuits (e.g., adders, multiplexers) and sequential circuits (e.g., flip-flops, counters).

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Semiconductor Junction:** Expressions for Fermi energy, Electron density in conduction band, Hole density in valence band, Drift of charge carriers (mobility & conductivity), Diffusion of charge carries and Life time of charge carries in a semiconductor. Work function in metals and semiconductors. Expressions for Barrier potential, Barrier width and Junction capacitance (diffusion & transition) for depletion layer in a PN junction. Expressions for Current (diode equation) and Dynamic resistance for PN junction. **Transistor Modeling**: Transistor as Two-Port Network. Notation for dc & ac components of voltage & current. Quantitative discussion of Z, Y & h parameters and their equivalent two-generator model circuits. h-parameters for CB, CE & CC configurations. Analysis of transistor amplifier using the hybrid equivalent model and estimation of Input Impedance, Output Impedance and Gain (current, voltage & power). **Number System**: Number Systems: Binary, Octal, Decimal & Hexadecimal number systems and their inter conversion. Binary Codes: BCD, Excess-3 (XS3), Parity, Gray, ASCII & EBCDIC Codes and their advantages & disadvantages. Data representation. **Binary Arithmetic**: Binary Addition, Decimal Subtraction using 9's & 10's complement, Binary Subtraction using 1's & 2's compliment, Multiplication and Division.	24
II	**Field Effect Transistors**: JFET: Construction (N channel & P channel); Configuration (CS, CD & CG); Operation in different regions (Ohmic or Linear, Saturated or Active or Pinch off & Break down); Important Terms (Shorted Gate Drain Current, Pinch Off Voltage & Gate Source Cut-Off Voltage); Expression for Drain Current (Shockley equation); Characteristics (Drain & Transfer); Parameters (Drain Resistance, Mutual Conductance or Transconductance & Amplification Factor); Biasing w.r.t. CS configuration (Self Bias & Voltage Divider Bias); Amplifiers (CS & CD or Source Follower); Comparison (N & P channels and BJTs & JFETs). MOSFET: Construction and Working of DE-MOSFET (N channel & P channel) and E-MOSFET (N channel & P channel); Characteristics (Drain & Transfer) of DE-MOSFET and E-MOSFET; Comparison of JFFET and MOSFET. **Other Devices**: SCR: Construction; Equivalent Circuits (Two Diodes, Two Transistors & One Diode-One Transistor); Working (Off state & On state); Characteristics; Applications (Static switch, Phase control system & Battery charger). UJT: Construction; Equivalent Circuit; Working (Cutoff, Negative Resistance & Saturation regions); Characteristics (Peak & Valley points); Applications (Trigger circuits, Relaxation oscillators & Sawtooth generators). **Logic Gates**: Truth Table, Symbolic Representation and Properties of OR, AND, NOT, NOR, NAND, EX-OR & EX-NOR Gates. Implementation of OR, AND & NOT gates (realization using diodes & transistor). De Morgan's theorems. NOR & NAND gates as Universal Gates. Application of EX-OR & EXNOR gates as pairty checker. Boolean Algebra. Karnaugh Map.	24

	Combinational & Sequential Circuits: Combinational Circuits: Half Adder, Full Adder, Parallel Adder, Half Substractor, Full Substractor. Data Processing Circuits: Multiplexer, Demultiplexer, Decoders & Encoders. Sequential Circuits: SR, JK & D Flip-Flops, Shift Register (transfer operation of Flip-Flops), and Asynchronous & Synchronous counters.	

Reference Books/ Text Books:

1. R.L. Boylestad, L. Nashelsky, “Electronic Devices and Circuit Theory”, Prentice-Hall of India Pvt. Ltd., 2015, 11e.
2. J. Millman, C.C. Halkias, Satyabrata Jit, “Electronic Devices and Circuits”, McGraw Hill, 2015, 4e.
3. B.G. Streetman, S.K. Banerjee, “Solid State Electronic Devices”, Pearson Education India, 2015, 7e.
4. J.D. Ryder, “Electronic Fundamentals and Applications”, Prentice-Hall of India Private Limited, 1975, 5e.
5. S.L. Gupta, V. Kumar, “Hand Book of Electronics”, Pragati Prakashan, Meerut, 2016, 43e.
6. D. Leach, A. Malvino, Goutam Saha, “Digital Principles and Applications”, McGraw Hill, 2010, 7e.
7. William H. Gothmann, “Digital Electronics: An Introduction to Theory and Practice”, Prentice-Hall of India Private Limited, 1982, 2e
8. R.P. Jain, “Modern Digital Electronics”, McGraw Hill, 2009, 4e

Course Outcome:

CO1- Study the drift and diffusion of charge carriers in a semiconductor.
CO2. Understand the Two-Port model of a transistor.
CO3. Study the working, properties and uses of FETs.
CO4. Comprehend the design and operations of SCRs and UJTs.
CO5. Understand various number systems and binary codes.
CO6. Familiarize with binary arithmetic.
CO7. Study the working and properties of various logic gates.
CO8. Comprehend the design of combinational and sequential circuits.

BPHC 0801: MECHANICAL PROPERTIES OF MATTER

OBJECTIVES: This Lab Course is aimed to experimentally determine the mechanical properties of materials including modulus rigidity, young modulus and surface tension. Through hands on experiments such as determining Poisson's ratio and acceleration due to gravity, students will develop skills in precise measurement and data analysis.

Credits: 02 **L–T–P: 0–0–4**

1. Moment of inertia of a flywheel
2. Moment of inertia of an irregular body by inertia table
3. Modulus of rigidity by statistical method (Barton's apparatus)
4. Modulus of rigidity by dynamical method (sphere / disc / Maxwell's needle)
5. Young's modulus by bending of beam
6. Young's modulus and Poisson's ratio by Searle's method
7. Poisson's ratio of rubber by rubber tubing
8. Surface tension of water by capillary rise method
9. Surface tension of water by Jaeger's method
10. Coefficient of viscosity of water by Poiseuille's method
11. Acceleration due to gravity by bar pendulum
12. Frequency of AC mains by Sonometer
13. Height of a building by Sextant
14. Study the wave form of an electrically maintained tuning fork / alternating current source with the help of cathode ray oscilloscope.

BPHC 0802: THERMAL PROPERTIES OF MATTER & ELECTRONIC CIRCUITS

OBJECTIVES: The objective of this lab course is to provide practical understanding of thermal and electronic behavior of materials and systems.

Credits: 02 **L–T–P: 0–0–4**

1. Mechanical Equivalent of Heat by Callender and Barne's method
2. Coefficient of thermal conductivity of copper by Searle's apparatus
3. Coefficient of thermal conductivity of rubber
4. Coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method
5. Value of Stefan's constant
6. Verification of Stefan's law
7. Variation of thermo-emf across two junctions of a thermocouple with temperature
8. Temperature coefficient of resistance by Platinum resistance thermometer
9. Charging and discharging in RC and RCL circuits
10. A.C. Bridges: Various experiments based on measurement of L and C
11. Resonance in series and parallel RCL circuit
12. Characteristics of PN Junction, Zener, Tunnel, Light Emitting and Photo diode
13. Characteristics of a transistor (PNP and NPN) in CE, CB and CC configurations
14. Half wave & full wave rectifiers and Filter circuits
15. Unregulated and Regulated power supply
16. Various measurements with Cathode Ray Oscilloscope (CRO)

BPHC 0803: DEMONSTRATIVE ASPECTS OF ELECTRICITY & MAGNETISM

OBJECTIVES: This lab will provide hands on experiments in exploring fundamental concepts of electricity and magnetism. Students will develop practical skills in instrumentation, data collection and analysis.

Credits: 02 **L–T–P: 0–0–4**

1. To study the variation of magnetic field along the axis of current carrying circular coil and then to estimate the radius of the coil.
2. To determine the resonant frequency in LCR circuit.
3. To calculate self-inductance by using Owen's bridge.
4. Find the high resistance by Leakage method.
5. Find the dielectric constant of a material by resonance method.
6. Conversion of galvanometer to ammeter and voltmeter.
7. To determine the unknown Inductance by Bridge Method.
8. Study of charging, discharging and time delay of a given capacitor.
9. Using Carey Foster Bridge determine the specific resistance of a given wire.
10. Study the Hall Effect and determine Hall coefficient, carrier density and mobility of a given semiconductor.

BPHC 0804: BASIC ELECTRONICS INSTRUMENTATION

OBJECTIVES: This lab will familiarize students with essential electronic instruments and measurement techniques. Students will learn to accurately measure voltage, current, frequency, and waveforms characteristics.

Credits: 02 **L–T–P: 0–0–4**

1. Transistor Bias Stability.
2. Comparative Study of CE, CB and CC amplifier.
3. Clippers and Clampers.
4. Study of Emitter Follower.
5. Frequency response of single stage RC coupled amplifier.
6. Frequency response of single stage Transformer coupled amplifier.
7. Effect of negative feedback on frequency response of RC coupled amplifier.
8. Study of Schmitt Trigger.
9. Study of Hartley oscillator.
10. Study of Wein Bridge oscillator.

BPHC 0805: DEMONSTRATIVE ASPECTS OF OPTICS & LASERS

OBJECTIVES: This lab aims to strengthen and develop skills in precise optical alignments, measurements and data analysis using optical and laser based systems.

Credits: 02 **L–T–P: 0–0–4**

1. Fresnel Biprism: Wavelength of sodium light.
2. Fresnel Biprism: Thickness of mica sheet).
3. Newton's Rings: Wavelength of sodium light.
4. Newton's Rings: Refractive index of liquid.
5. Plane Diffraction Grating: Resolving power.
6. Plane Diffraction Grating: Spectrum of mercury light.
7. Spectrometer: Refractive index of the material of a prism using sodium light.
8. Spectrometer: Dispersive power of the material of a prism using mercury light.
9. Polarimeter: Specific rotation of sugar solution.
10. Wavelength of Laser light using diffraction by single slit.

BPHC 0806: ANALOG & DIGITAL CIRCUITS

OBJECTIVES: This lab will provide hands-on experience in analyzing both analog and digital electronic circuits. Students will work with components such as p-n junction, transistor and logic gates to understand circuit behavior and functionality.

Credits: 02 **L–T–P: 0–0–4**

1. Energy band gap of semiconductor by reverse saturation current method.
2. Energy band gap of semiconductor by four probe method.
3. Hybrid parameters of transistor.
4. Characteristics of FET, MOSFET, SCR, UJT.
5. FET Conventional Amplifier.
6. FET as VVR and VCA.
7. Study and Verification of AND gate using TTL IC 7408.
8. Study and Verification of OR gate using TTL IC 7432.
9. Study and Verification of NAND gate and use as Universal gate using TTL IC 7400.
10. Study and Verification of NOR gate and use as Universal gate using TTL IC 7402.
11. Study and Verification of NOT gate using TTL IC 7404.
12. Study and Verification of Ex-OR gate using TTL IC 7486.

BPHC 0021: ELEMENTS OF NANOMATERIALS

OBJECTIVES: To help the students understand a broad outline and fundamental knowledge of Nanoscience and Nanotechnology.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Introduction to Nanotechnology:** Definition of Nanoscale system, Feymann theory of Nanotechnology, Term: Nanoscience & Nanotechnology, Molecular and atomic size, Difference b/w bulk and nano material. **Nanostructures:** Carbon Nanotubes (CNT), Graphene, Fullerenes, Semiconductor Nanoparticles, Metal-based Nanostructures, Nanowires, ultra-thin films, multi-layered materials. Applications of nanomaterials. **Quantum Confinement -** Quantum confinement in one dimension (Quantum walls), Quantum confinement in two dimensions (Quantum wires), Quantum confinement in three dimensions (Quantum dots). Density of states (1-D,2-D,3-D) and Band structure, Size Effects in nano systems. **Properties of Nanomaterials**: Changes in properties at nanoscale. Mechanical, Electrical, Optical, Thermal and Chemical properties of nanomaterials.	24
II	**Synthesis of Nanomaterials:** Preparation methods: Bottom-up and Top-down Approach- Photolithography. Ball milling. Precipitation, Mechanical Milling, Colloidal routes, Self-assembly, Sol – Gel synthesis. Physical deposition- Sputtering, Evaporation: Chemical Vapour Deposition- ALD, PECVD, LPCVD. Spray pyrolysis. Hydrothermal synthesis. Molecular Beam Epitaxy, Atomic Layer Epitaxy. **Characterization Techniques**: X-Ray Diffraction, UV Spectroscopy. Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM).	24

Reference Books/ Text Books

1. C.P.Poole, Jr. Frank J.Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology
4. V.V. Mitin, V.A. Kochelap and M.A. Stroscio, Introduction to Nanoelectronics.
5. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

Course Outcome

CO1-understand the difference between bulk and nanomaterials, and significance of particle at nanoscale.
CO2-Familiar with different types of nanostructures, their properties and applications.
CO3-understand the nanostructures based on quantum confinement and their density of states variation with energy.
CO4-Familiar with the different physical and chemical methods of synthesis of nanomaterials.
CO5-understand the different characterization techniques used to study nanomaterials and their importance.

BPHC 0022: WAVES & OSCILLATIONS

OBJECTIVES: Provide knowledge of fundamental laws governing to motion of all types of waves especially SHM. To make the students familiar with the damped SHM and forced SHM.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Wave motion:** Progressive harmonic wave, differential equation of wave motion, energy density of plane progressive wave, superposition of wave, beats, propagation of longitudinal and transverse vibration along string, modes of vibration, Fourier's theorem, La'place correction of Newton's formula, group velocity and phase velocity. **Simple Harmonic Motion - I:** Periodic and harmonic motion, simple harmonic motion, energy of harmonic oscillator, average value of kinetic and potential energy of H.O. mass spring system.	24
II	**Simple Harmonic Motion - II:** Two body harmonic oscillator, oscillation of diatomic molecule, time period of pendulum of large amplitude. Kapler's laws and its applications, equation of orbit, anharmonic motion. **Damped and forced Harmonic Motion:** Frictional effects-(damping), damped harmonic oscillator, power dissipation, quality factor (Q), example of damped H.O, driving (forced) harmonic oscillator, sharpness of resonance, phase of driving Oscillator, Velocity resonance, half width of resonance curve, power absorption. Superposition principle driving L-C-R circuit, parallel resonance circuit, example and application. **Acoustic wave**: Basics, types of acoustic waves, boundary conditions for acoustic wave propagation. Transducers and sensors for acoustic waves.	24

Reference Books/ Text Books

* Physics Part –1: Resanick and Halliday.
* Mechanics : D.S.Mathur.
* Concept in Physics Vol. I : H.C.Verma.
* Mechanics : R.K.Shukla and Anchal Srivastava
*Classical Mechanics: J.C Upadhyay

Course Outcomes

CO1: Discuss different type of waves and their properties and obtain differential equation of wave motion.

CO2: Discuss superposition of wave, beats and propagation of longitudinal and transverse vibration along string, modes of vibration, La'place correction of Newton's formula.

CO3: Explain Periodic, harmonic motion, simple harmonic motion and calculate energy of harmonic oscillator like mass spring system.

CO4: Learn about two body harmonic oscillator, oscillation of diatomic molecule and calculation of time period of pendulum of large amplitude.

CO5: Understand Kapler's laws and its applications, equation of orbit, anharmonic motion.

CO6: Discuss Damped and forced Harmonic Motion of different physical systems.

BPHC 0023: ATOMIC AND MOLECULAR PHYSICS

OBJECTIVES: The objective of offering this course to the UG Students to make them aware about the construction of an atom, origin of atomic spectra, X-ray spectra and generation of laser beam.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Atomic Physics**: Bohr's atomic model and its limitations, Sommerfeld model and qualitative discussions about relativistic correction, Idea of discrete energy levels and electron spin: Franck-Hertz and Stern–Gerlach experiments, Quantum numbers and their significance, Pauli's exclusion principle, concept of atomic orbitals, Hunde rule. **One electron atoms**: Orbital magnetic moment, orbital, spin and total angular momenta, Larmor precession, vector atomic model, electronic configuration and atomic states. **Two electrons/many electrons atoms**: Idea about spin orbit interaction, fine structure, selection rules, L-S and j-j coupling scheme in two valence electron atoms, alkali spectra, intensity of spectral lines, Lande 'g' factor, Zeeman effect (normal), qualitative idea about Stark effect.	24
II	**X-Ray Spectroscopy**: Production of X-Rays and their properties, continuous X-Ray spectrum and its dependence on voltage, Duane and Hunt law, characteristic X-Rays. **Molecular Physics:** **Rotational spectra:** Diatomic molecule as rigid rotator: explanation of rotational spectra, limitations of rotational spectra, Diatomic molecule as non-rigid rotator. **Vibrational Spectra:** Diatomic molecule as harmonic and harmonic oscillator, isotopic effect on vibrational levels, rotational vibrational spectra, thermal distribution of rotational vibrational levels, fundamental modes of H_2O and CO_2.	24

Reference Books/ Text Books

1. Atomic Physics by J.B. Rajam, S.Chand & Company Limited.
2. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and particles by Robert Eisberg and Robert Resnick, John Wiley & Sons.
3. Physics of atoms and molecules, B. H. Bransden and C. J. Joachain, Pearson.
4. Atom, Laser and Spectroscopy, S.N. Thakur and D.K. Rai, Prentice Hall of India.
5. Nuclear Physics by D C Tayal, Himalyan Publications.
6. Atomic and Molecular spectra: Laser by Raj Kumar, Kedarnath Ramnath publishing house.

Course Outcomes: On the completion of the syllabus the students are able

1. To describe the various models, Atomic structure, electron spin, quantum numbers with their significance, atomic orbitals and importance of Hund`s rule.
2. To discuss the one electron atoms, vector atom model, electronic configuration, Larmor precession and atomic states.
3. To state and explain the two/many electron atoms properties of such atoms orbital couplings (L-S and J-J coupling), change in behavior of atoms under external electric and magnetic field.
4. To understand the principles of X- ray spectroscopy, production, dependency and characteristics of X-ray with the knowledge of Duane and Hunt law.
5. To discuss the rotational spectra of diatomic molecule, rigid rotator, non-rigid rotator and limitations of rotational spectra.
6. To explain the vibrational spectra of diatomic molecules, isotopic effect, rotational vibration spectra and fundamental modes of H_2O and CO_2 molecules.

BPHC 0024: ELECTRONIC DEVICES AND CIRCUITS

OBJECTIVES: To provide a comprehensive understanding of electronic devices and circuits.

Credits: 04 **Semester VI** **L–T–P: 5–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Network Analysis:** Review of Kirchhoff's Current Law & Kirchhoff's Voltage Law. Ideal constant-voltage and constant-current sources. Mesh & Node Analysis. Thevenin theorem, Norton theorem, Maximum Power Transfer theorem. Applications to dc circuits. **Devices:** Field effect transistors, I-V Characteristics of JFET and MOSFET, FET biasing, FET as an amplifier. Silicon controlled rectifier and I-V Characteristics, phase controlled rectifier. Uni-junction transistor and I-V Characteristics, relaxation oscillator. **Opto-electronic devices & characteristics**: Photo diode, Phototransistor, Light emitting diode and solar cell.	28
II	**Amplifiers:** Need of Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. RC-coupled amplifier and its frequency response. Direct coupled (DC amplifier), Concept of Feedback in Amplifiers, Positive and Negative Feedback. Effect of negative feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **Oscillator:** Barkhaussen criterion of oscillations, tuned collector oscillator, Hartley / Colpitt oscillator, phase shift oscillator, Wien's Bridge oscillator. **Digital Circuits:** Logic gates, NAND and NOR gates as universal gates. Boolean algebra.	28

Reference Books/ Text Books

1. Introductory Circuit Analysis, Robert L. Boylestad, Twelfth edition, Pearson, 2012.
2. Introduction to Electric Circuits, Richard C. Dorf and James A. Svoboda, Wiley India Private Limited, Sixth Edition, 2007.
3. Electronic Devices and Circuit Theory Introductory Circuit Analysis, Robert L. Boylestad and Louis Nashelsky, Pearson, Tenth Edition, 2007.

Course Outcomes:

CO1 To impart knowledge on Kirchhoff's current law and Kirchhoff's voltage law.
CO2 To understand the concept of Mesh & Node Analysis, and application of Thevenin theorem, Norton theorem, Maximum Power Transfer theorem.
CO3 To impart knowledge on the operations and characteristics of JFET, MOSFET and different rectifiers.
CO4 To impart knowledge on different power amplifier circuits, their design and their characteristics
CO5 Understand the operation and characteristics of the various oscillators.
CO6 To impact knowledge logic gates and their applications.

BPHO 0004: ASTRONOMY AND ASTROPHYSICS

OBJECTIVES: To provide understanding of origin and evolution of the Universe. This course gives an overview on key developments in observational astrophysics.

Credits: 04 **Semester VI** **L–T–P : 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Basic Astronomical Parameters:** Astronomical scales (Distance, Mass and Time), Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus, Measurement of Astronomical Quantities (Distances, Stellar Radii, Masses of Stars from binary orbits, Stellar Temperature, Color index of stars). **Basic concepts of positional astronomy:** Celestial Sphere, Geometry of a Sphere, Astronomical Coordinate Systems, Horizon System, Equatorial System, Coordinate transformation between Horizon and Equatorial system, Diurnal Motion of the Stars. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Julian Date.	24
II	**Astronomical telescopes and techniques:** Atmospheric Windows, Optical telescopes, Radio telescope, Telescope mountings, Magnification, Light gathering power, resolving power and diffraction limit, Detection limit of telescope, Modern terrestrial and space telescopes (GMRT, Keck, Chandra, HST) **The Sun and the Solar System:** Solar Atmosphere, Solar Photosphere, Chromosphere, Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics, Origin of the Solar System (The Nebular Model, Tidal Forces, Planetary Rings and their formation); ExtraSolar Planets.	24

Reference Books/ Text Books

1. An Introduction to Modern Astrophysics and Cosmology (Second Edition), B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co., 2006
2. Introductory Astronomy and Astrophysics (Fourth Edition), M. Zeilik and S. A. Gregory
3. Saunders College Publishing, 1998 Fundamental of Astronomy (Fifth Edition), H. Karttunen et al. Springer, 2007

Course Outcomes:

CO1 Understanding of the measurement of basic astronomical parameters such as astronomical scales, astronomical quantities and luminosity.
CO2 Understanding of positional astronomy and planetary motion.
CO3 Formation of planetary system and its evolution with time
CO4 Knowledge of the instrument detectors, telescope optics and the choice of observation sites.
CO5 Basic knowledge of the physical properties of Sun and the components of the solar system.

BPHE 0001: OPTICS

OBJECTIVES: This course is designed to give knowledge of principles of wave optics to graduate students. Students will able to understand the basic phenomenon of interference, diffraction, polarization and their uses in different optical devices.

Credits: 03 L-T-P: 3-0-0

Module No.	Content	Teaching Hours (Approx.)
I	**Interference:** Basics of Inference, Fresnel biprism, determination of wavelength, Newton's ring, Conditions for sustained interference, Theory of interference, Interference in parallel and wedge shaped films, Colors of thin film, Newton's rings, Applications of Newton's ring. **Diffraction:** Fraunhoffer diffraction due to single, N-slits (grating) qualitative explanation of N-slits diffraction direction of principle maxima, maximum number of order with plane transmission grating, Rayleigh criterion of resolution, Resolving and dispersive power of grating.	18
II	**Polarization:** Polarization by double refraction and Huygen's theory, Nicol prism, Retardation plates, Production and analysis of circularly and elliptically polarized light. Optical activity and Fresnel's theory, Biquartz polarimeter. **Laser and Optical Fiber:** Basic concept of Laser, properties of laser beam, Einstein's coefficients, Ruby laser, He-Ne Laser. Optical fiber, light propagation mechanism, advantages and disadvantages of optical fiber, applications of optical fiber.	18

Reference Books/ Text Books

1. Physical Optics: B. K. Mathur and T. P. Pandya.
2. A textbook of Optics: N. Subrahmanyam, Brijlal and M. N. Avadhanulu.
3. Geometrical and Physical Optics: Longhurst.
4. Introduction to Modern Optics: G. R. Fowels.
5. Optics: P. K. Srivastav
6. Optics: Ajoy Ghatak

Course Outcomes

CO1- Understand phenomenon of interference due to division of wave front and division of amplitude and variation of intensities in this phenomenon
CO2- Explain the phenomena of diffraction of light waves due to single slit and N slits.
CO3- Learn the concepts of Rayleigh criterion, resolving and dispersive power of grating.
CO4- Understand the concepts of Polarization.
CO5- Analyze concepts of different types of Laser.
CO6- Obtain the basic knowledge of optical fiber

BPHE 0002: FUNDAMENTALS OF WAVES AND OSCILLATIONS

OBJECTIVES: Provide knowledge of fundamental laws governing to motion of all types of waves especially SHM. To make the students familiar with the damped SHM and forced SHM.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Wave motion:** Basics of wave motion, differential equation of wave motion, energy density of plane progressive wave, superposition of wave, beats, propagation of longitudinal and transverse vibration along string, modes of vibration, group velocity and phase velocity. **Simple Harmonic Motion - I:** Periodic and harmonic motion, simple harmonic motion, energy of harmonic oscillator, average value of kinetic and potential energy of H.O. mass spring system.	18
II	**Simple Harmonic Motion - II:** Two body harmonic oscillator, oscillation of diatomic molecule, time period of pendulum of large amplitude. **Damped and forced Harmonic Motion:** Frictional effects-(damping), damped harmonic oscillator, power dissipation, quality factor (Q), example of damped H.O, driving (forced) harmonic oscillator, sharpness of resonance, phase of driving oscillator, velocity resonance, half width of resonance curve, power absorption. Applications of resonance. Superposition principle driving L-C-R circuit, parallel resonance circuit and its example.	18

Reference Books/ Text Books

1. Physics Part –1: Resanick and Halliday.
2. Mechanics: D.S.Mathur.
3. Concept in Physics Vol. I: H.C.Verma.
4. Classical Mechanics: J.C Upadhyay

Course Outcomes

CO1: Discuss different type of waves and their properties and obtain differential equation of wave motion.

CO2: Discuss superposition of wave, beats and propagation of longitudinal and transverse vibration along string, modes of vibration.

CO3: Explain Periodic, harmonic motion, simple harmonic motion and calculate energy of harmonic oscillator like mass spring system.

CO4: Learn about two body harmonic oscillator, oscillation of diatomic molecule and calculation of time period of pendulum of large amplitude.

CO5: Understand Damped and forced Harmonic Motion of different physical systems.

CO6: Learn about the applications of superposition of waves in electronic circuits.

BPHE 0003: HEAT AND THERMODYNAMICS

OBJECTIVES: Gain the basic knowledge and principles of heat and thermodynamics and analyze different thermodynamical systems based on these principles.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	Thermodynamic systems, Thermodynamic processes: Isothermal, Isobaric, Isochoric and adiabatic, Work done, Internal energy, reversible and irreversible processes, Thermal equilibrium and Zeroth law of thermodynamics, First law of thermodynamics and its applications, Carnot's cycle and Carnot's theorem, Heat Engine, Second law of thermodynamics. Concept of entropy, Entropy and disorder, Entropy change in reversible and irreversible processes, principle of increase of entropy, Entropy of ideal gases, Entropy as a thermodynamic variable, S-T diagram.	24
II	Thermodynamic functions, Internal energy, Enthalpy, Helmholtz function and Gibb's free energy, Maxwell's Thermodynamical equations and their applications, TdS equations, Energy and heat capacity equations Clapeyron equations. Third law of thermodynamics, Nernst heat theorem. Criterion of equilibrium of a system, Isolated system, System in contact with constant temperature reservoir, Phase transition, Triple point, Joule Expansion, Joule-Thomson Expansion, Thermodynamic analysis, Inversion temperature.	24

Reference Books/ Text Books

1. Heat and Thermodynamics: K.W. Zeemansky.
2. Thermal Physics: B.K. Agarwal.
3. Heat and Thermodynamics: Brij Lal and N. Subramanyam.
4. A Treatise on Heat: M.N. Saha and B.N. Srivastava.

Course Outcomes

CO1: Understand the various kind of thermodynamical processes.

CO2: Explain zeroth, first and second law of thermodynamics.

CO3: Understand the application of Carnot's engine and concepts of entropy.

CO4: Understand the relationship between different thermodynamical variables.

CO5: Explain the third law of thermodynamics and condition for equilibrium of a system.

CO6: Understand the phase transition and Joule-Thomson effect in a thermodynamical system.

BPHE 0004: ATOMIC PHYSICS

OBJECTIVES: The objective of offering this course to the UG Students to make them aware about the construction of an atom, origin of atomic spectra, X-ray spectra.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Atomic Physics**: J.J. Thomson atomic model, Rutherford atomic model, Bohr's atomic model and its limitations, Sommerfeld model and qualitative discussions about relativistic correction, Idea of discrete energy levels and electron spin: Franck-Hertz and Stern–Gerlach experiments, Quantum numbers and their significance, Pauli's exclusion principle, concept of atomic orbitals, Hunde rule. **One electron atoms**: Orbital magnetic moment, orbital, spin and total angular momenta, Larmor precession, atomic vector model, electronic configuration and atomic states.	24
II	**Two electrons/many electrons atoms**: Idea about spin orbit interaction, fine structure, selection rules, L-S and j-j coupling scheme in two valence electron atoms, alkali spectra, intensity of spectral lines, Lande 'g' factor, Zeeman effect (normal), qualitative idea about Stark effect. **X-Ray Spectroscopy**: Production of X-Rays and their properties, continuous X-Ray spectrum and its dependence on voltage, Duane and Hunt law, characteristic X-Rays, Moseley's law, doublet structure and screening parameter in X-Ray Spectra.	24

Reference Books/ Text Books

1. Atomic Physics by J.B. Rajam, S.Chand & Company Limited.
2. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and particles by Robert Eisberg and Robert Resnick, John Wiley & Sons.
3. Physics of atoms and molecules, B. H. Bransden and C. J. Joachain, Pearson.
4. Atom, Laser and Spectroscopy, S.N. Thakur and D.K. Rai, Prentice Hall of India.
5. Atomic and Molecular spectra: Laser by Raj Kumar, Kedarnath Ramnath publishing house.

Course Outcomes

CO1: To describe the various atomic models, Atomic structure, electron spin, quantum numbers with their significance, atomic orbitals, discrete energy levels, relativistic corrections and importance of Pauli`s exclusion principle and Hund`s rule.

CO2: To discuss the one electron atoms, vector atom model, electronic configuration, different magnetic moments, Larmor precession and atomic states.

CO3: To state and explain the two/many electron atoms properties of such atoms orbital couplings (L-Sand J-J coupling), Alkali spectra, intensity of spectral lines, Lande `g` factor.

CO4: To explain the change in behavior of atoms under external electric and magnetic field (Normal and Anomalous Zeeman`s effects, stark effect.).

CO5: To make understand the principles of X- ray spectroscopy, production, dependency and characteristics of X-ray.

CO6: To describe the dependence of X-ray on voltage, Duane and Hunt law, Moseley`s law, Doublet structure and X-ray parameter in X-ray spectra.

BPHE 0005: SOLAR AND ASTROPHYSICS

OBJECTIVES: To provide understanding of origin and evolution of the Universe. This course gives an overview on key developments in observational astrophysics.

Credits: 04 **L–T–P: 4–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Sun & Solar Phenomena:** Structure of the Sun: Solar interior, solar atmosphere, photosphere, chromosphere, corona; Small & large scale Solar structures, Sun spots and their properties, Prominences, Solar Flare: classifications, phases & flare theory; Solar cycle, Solar magnetic field. **Solar Wind:** Observed and derived properties of solar wind, Solar wind formation: Fluid theory for static as well as expanding isothermal solar atmosphere, Spatial configuration of magnetic field frozen into solar wind, Termination of solar wind, Heliosphere.	24
II	**Overview of the Universe:** Qualitative description of astro-objects (from planets to large scale structures): length mass and time scales, Evolution of structures in the universe; Red shift, Expansion of the universe. **Astrophysical Processes:** Simple orbits, Kepler's laws, Flat rotation curve of galaxies and implications for dark matter, Role of gravity in different astrophysical systems; Radiative Process: Radiation theory and Larmor formula, Different radiative processes.	24

Reference Books/ Text Books

1. Astrophysics of the Sun: Harold Zirin, Cambridge University Press, Cambridge, U.K.
2. Solar System Astrophysics: J.C. Brandt & P.W. Hadge
3. Guide to the Sun: Kenneth J. H. Philips, Cambridge University Press, U.K.
4. An Introduction to Modern Astrophysics: W. Carroll & D. A. Ostlie, Addison Wesley
5. The Physics of Astrophysics Vol I & II: Frank H. Shu, University Science Books, USA

Course Outcomes:

CO1: Basic knowledge of the physical properties of Sun and the components of the solar system.
CO2: Learn about formation of solar wind and its termination.
CO3: Understanding of structures and expansion universe, Red shift.
CO4: Understand the Kepler's laws and its applications in astrophysical processes.
CO5: Knowledge of dark matter, radiation theory and various radiative processes.

BPHE 0801: OPTICS LAB

OBJECTIVES: This lab aims to strengthen and develop skills in handling spectrometer, polarimeter and optical fiber. Students will learn about the alignment of optical instruments and precise measurements.

Credits: 01 **L–T–P: 0–0–2**

1. Wavelength of monochromatic light with the help of Fresnel's biprism.
2. Wavelength of monochromatic light by Newton's rings.
3. Refraction index of the material of the prism for the given colour (wavelengths) of mercury light with the help of a spectrometer.
4. Wavelength of spectral lines using plane transmission /diffraction grating.
5. Wavelength of LASER light by diffraction grating.
6. Specific rotation using Biquartz Polarimeter.
7. To find the polarization angle of laser light using polarizer and analyzer.
8. Focal length of combination of two lenses separated by distance *d* and verify the formula $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$.
9. Polarization of light by simple reflection.
10. Fiber optic trainer for numerical aperture.

BPHE 0802: WAVES & OSCILLATIONS LAB

OBJECTIVES: Objective of this lab is to help students to understand the fundamentals of principles of wave motion and oscillatory systems through hands-on experiments.

Credits: 01 **L–T–P: 0–0–2**

1. To determine the value of acceleration due to gravity in the laboratory by bar pendulum.
2. To determine the value of acceleration due to gravity at a place by means of Kater's reversible pendulum.
3. To find the moment of inertia of the disc and the rigidity modulus of the material of the suspension wire subjected to torsional oscillations.
4. To study method of frequency measurement using a CRO.
5. To determine the frequency of AC Mains with the help of Sonometer.
6. To determine the frequency of AC Mains using an electric vibrator.
7. To determine the frequency of an electrically maintained tuning fork by Melde's method.
8. To determine the moment of inertia of a body by inertia table.
9. To determine the modulus of rigidity of the material of a given wire by a dynamical method using Maxwell's needle.

BPHO 0001: SCIENCE AND TECHNOLOGY OF HYDROGEN ENERGY

OBJECTIVES: The objective is to make students fundamentally strong about Hydrogen Energy production, storage and utilization so that petroleum use, greenhouse gas emissions, and air pollution can be reduced.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Fundamentals, Production and Storage:** Relevance in relation to depletion of fossil fuels and environmental considerations. Solar Hydrogen through Photoelectrolysis, Physics of material characteristics for production of Solar Hydrogen. Brief discussion of various storage processes, special features of solid hydrogen storage materials, Structural and electronic characteristics of storage materials. New Storage Modes.	18
II	**Safety and Utilization:** Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Various type of Fuel Cells, Applications of Fuel Cell, Elementary concepts of other Hydrogen Based devices such as Hydride Batteries.	18

Reference Books/ Text Books

1. Hydrogen as an Energy Carrier Technologies Systems Economy: Winter & Nitch (Eds.)
2. Hydrogen as a Future Engery Carrier: Andreas Zuttel, Andreas Borgschulte and Louis Schlapbach

BPHO 0002: SCIENCE AND TECHNOLOGY OF SOLAR ENERGY

OBJECTIVES: The objective is to make students fundamentally strong about Solar Energy utilization by analyzing efficiency of solar cells so that petroleum use, greenhouse gas emissions, and air pollution can be reduced.

Credits: 03 **L-T-P: 3-0-0**

Module No.	Content	Teaching Hours (Approx.)
I	**Fundamental and Material Aspects:** Fundamentals of photovoltaic Energy Conversion Physics and Material Properties, Basic to Photovoltaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.	18
II	**Different Types of Solar Cells:** Types of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief description of single crystal silicon and organic and Polymer Solar Cells, Elementary Ideas of Advanced Solar Cells e.g. Tandem Solar cells, Solid Liquid Junction Solar Cells, Nature of Semiconductor, Principles of Photoelectrochemical Solar Cells.	18

Reference Books/ Text Books

1. Solar Cell Devices-Physics: Fonash
2. Fundamentals of Solar Cells Photovoltaic Solar Energy: Fahrenbruch & Bube
3. Phoptoelectrochemical Solar Cells: Chandra

BPHO 0003: SATELLITE COMMUNICATION AND REMOTE SENSING

OBJECTIVES: To make the students familiar with basics principles of satellite communication and its uses. To aware the students with different types of remote sensing, remote sensing platforms and sensors.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Principle of Satellite Communication:** General and Technical characteristics, Active and Passive satellites, Modem and Codec. **Communication Satellite Link Design:** General link design equation, Atmospheric and Ionospheric effect on link design, Earth station parameters. **Satellite Analog Communication:** Baseband analog signal, FDM techniques, S/N and C/N ratio in FM in satellite link.	18
II	**Concept and Foundations of Remote Sensing:** Electromagnetic Radiation (EMR), Interaction of EMR with Atmosphere and Earth surface, Application areas of Remote Sensing. **Characteristics of Remote Sensing Platforms & Sensors:** Ground, Air & Space platforms, Return Beam Vidicon, Multi-spectral Scanner. **Microwave Remote Sensing:** Microwave sensing, RADAR: SLAR & applications, LIDAR: basic components & applications.	18

Reference Books/ Text Books

1. Satellite Communication – D.C. Agrawal & A. K. Maini.
2. Satellite Communication – T. Pratt and C. W. Bostiern
3. Satellite Communication Systems-M. Richharia, MacGraw Hill.
4. Introduction to Remote Sensing – J. B. Campbell.
5. Manual of Remote Sensing: Vol I & II, Edited by R. N. Colwell, American Society of Photogrammetry.

BPHO 0011: RADIATION SAFETY

OBJECTIVES: The objective of the course is to study the applications of nuclear techniques and radiation protection. It will provide knowledge of the protective measures against the radiation exposure.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Basics of Atomic and Nuclear Physics:** Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half-life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission. **Interaction of Radiation with matter:** Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, Interaction of Photons - Photoelectric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons- Collision, slowing down and Moderation.	18
II	**Radiation detection and monitoring devices:** Radiation Quantities and Units: Basic idea of different units of activity, Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Geiger Muller Counter), Scintillation Detectors. **Radiation safety management:** Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management, Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy).	18

Reference Books/ Text Books

1. Nuclear and Particle Physics by W. E. Burcham and M. Jobes, Harlow Longman Group, 1995.
2. G. F. Knoll, Radiation detection and measurement, 4th Edition, Wiley Publications, 2010.
3. Thermoluminescence dosimetry by A. F. Mcknlay, Bristol, Adam Hilger
4. Fundamental Physics of Radiology by W .J. Meredith and J.B. Massey, John Wright and Sons,UK, 1989.

BPHO 0012: APPLIED OPTICS

OBJECTIVES: To aware the students about light sources and detectors. To provide the students fundamental knowledge about lasers, holography and optical fibres.

Credits: 03 **L-T-P: 3-0-0**

Module No.	Content	Teaching Hours (Approx.)
I	**Photo-sources and Detectors Lasers:** an introduction, Planck"s radiation law (qualitative idea), Energy levels, Absorption process, Spontaneous and stimulated emission processes, Theory of laser action, Population of energy levels, Einstein"s coefficients and optical amplification, properties of laser beam, Ruby laser, He-Ne laser, and semiconductor lasers; Light Emitting Diode (LED) and photo-detectors. **Holography**: Introduction, Basic principle and theory: recording and reconstruction processes, Requirements of holography-coherence, etc.	18
II	**Photonics: Fibre Optics Optical fibres:** Introduction and historical remarks, Total Internal Reflection, Basic characteristics of the optical fibre: Principle of light propagation through a fibre, the coherent bundle, The numerical aperture, Attenuation in optical fibre and attenuation limit; Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating.	18

Reference Books/ Text Books

1. LASERS: Fundamentals & applications, K.Thyagrajan& A.K.Ghatak, 2010, Tata McGraw Hill
2. Introduction to Fourier Optics, Joseph W. Goodman, The McGraw- Hill, 1996.
3. Introduction to Fiber Optics, A. Ghatak & K. Thyagarajan, Cambridge University Press

BPHO 0013: RENEWABLE ENERGY AND ENERGY HARVESTING

OBJECTIVES: To aware the students about conceptual understanding of clear energy sources like solar energy, wind energy, hydro energy and bioenergy technologies.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Fossil fuels and Alternate Sources of energy:** Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. **Solar energy:** Solar energy, its importance, storage of solar energy, solar water heater, flat plate collector, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits. **Wind Energy harvesting:** Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces.	18
II	**Ocean Energy & Geothermal Energy:** Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices, Geothermal Resources, Geothermal Technologies. **Hydro Energy**: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. **Piezoelectric Energy harvesting:** Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric energy harvesting applications. Environmental issues and sustainability.	18

Reference Books/ Text Books

1. Non-conventional energy sources, B.H. Khan, McGraw Hill
2. Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
3. Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rd Edn., 2012, Oxford University Press.
4. Renewable Energy, 3rd Edition,
5. Solar Energy: Resource Assesment Handbook, P Jayakumar, 2009

BPHO 0014: BASIC INSTRUMENTATION SKILLS

OBJECTIVES: To expose the students about various aspects of instruments and their usages. The course will train the students different day to day life analog and digital equipments.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Basic of Measurement:** Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. **Electronic Voltmeter**: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only).Specifications of an electronic Voltmeter/ Multimeter and their significance.AC millivoltmeter: Type of AC millivoltmeters, Block diagram ac millivoltmeter, specifications and their significance.	18
II	**Oscilloscope:** Block diagram of basic CRO. CRT, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence. Time base operation, synchronization. Front panel controls. Specifications of CRO and their significance. Use of CRO for the measurement of voltage (dc and ac), frequency and time period. Special features of dual trace. **Digital Instruments:** Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. **Digital Multimeter:** Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution.	18

Reference Books/ Text Books

1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and design of AC machines - M G Say ELBS Edn.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Logic circuit design, Shimon P. Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.

BPHO 0015: ELECTRICAL CIRCUITS AND NETWORK SKILLS

OBJECTIVES: The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances.

Credits: 03 **L–T–P: 3–0–0**

Module No.	Content	Teaching Hours (Approx.)
I	**Basic Electricity Principles:** Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC and DC Electricity. Familiarization with multimeter, voltmeter and ammeter. **Electrical Circuits**: Basic electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money. **Electrical Drawing and Symbols:** Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.	18
II	**Generators and Transformers:** DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers. **Solid-State Devices:** Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources **Network Theorems:(**1) Thevenin theorem (2) Norton theorem (3) Superposition theorem (4) Maximum Power Transfer theorem	18

Reference Books/ Text Books

1. Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
2. A text book in Electrical Technology - B L Theraja - S Chand & Co.
3. A text book of Electrical Technology - A K Theraja
4. Performance and design of AC machines - M G Say ELBS Edn.