



DEPARTMENT OF PHYSICS
(SCHOOL OF PHYSICAL SCIENCES)

CENTRAL UNIVERSITY OF RAJASTHAN

Four Year Undergraduate Program

The Four Year Undergraduate Program (FYUG) in Physics offered by the Central University of Rajasthan is designed to give students a strong foundation in the subject and keep them updated with the latest advancements as per NEP 2020. The program's multidisciplinary structure allows students to explore the intersections of physics with other fields of study, cultivating a broader perspective and enhancing their understanding of interconnected knowledge areas. Designed to promote critical thinking, problem-solving abilities, and creativity, the syllabus includes laboratory work and practical exercises that enable students to apply theoretical concepts to real-world problems and enhance their scientific skills. As the students transitioning from senior secondary education face crucial decisions regarding their career paths, the program equips students with the skills and knowledge necessary for success in a rapidly changing world.

The FYUG program in Physics comprises Core courses, Minor courses, Elective courses, Ability enhancement courses, Value added courses, and Skill enhancement courses etc. As per NEP's recommendations, the FYUG program in Physics also offers multiple exit options. A student can choose to exit the FYUG program after each year of study and accordingly will be awarded the following degree/certificate:

1. **UG Certificate:** A certificate after completing 1 year of study.
2. **UG Diploma:** A diploma after completing 2 years of study.
3. **B. Sc. (Hons):** A Bachelor's degree after completion of 3-years.
4. **B. Sc. (Hons with Res):** A Bachelor's degree with Research after completing 4 years.

Similarly, the department offers lateral entry to FYUG program in 2nd, 3rd and 4th year subject to minimum eligibility for the program with completion of 44, 84 and 120 valid academic bank credits (ABC) respectively. The department admission committee shall also look for equivalence and advise for additional courses (if any).

PROGRAM OUTCOMES (PO)

- Appreciation for all natural science subjects (PO-1)
- Learn to carry out experiments in basic as well as in certain advanced areas of physics and to gain hands-on experience to work in applied fields (PO-2)
- Able to communicate topics of physics to peers, experts from other disciplines and the general public essential for collaborative work with a diverse team (PO-3)
- Building foundation for higher studies as well as enhancing capabilities to get science jobs (PO-4)
- Development of scientific attitude, analytical and rational thinking, positive attitudes to realize the importance of hard work, commitment, ethics and excellence (PO-5)
- Unafraid of taking challenging tasks, responsibilities, flexible in dealing with conflicting issues obligatory to become future entrepreneurs and innovators (PO-6)

Credit framework of FYUG Academic Programme at CURAJ as per NEP-2020

Qualification	Credits	Semester wise credit break up									VSC
		Semesters	Major	Minor	IDC	SEC	AEC	VAC	RP	Semester Credits	
UG Certificate	44	I	4	4	3	3	2	4	—	20	4
		II	4	4	3	3	2	4	—	20	
UG Diploma	84	III	8	4	3	3	2	—	—	20	4
		IV	12	4	—	—	2	—	2	20	
B.Sc.	120	V	16	4	—	—	—	—	—	20	
		VI	16	4	—	—	—	—	—	20	
B.Sc. (Hons) / B. Sc. (Hons with Res)	160	VII	12	8	—	—	—	—	—	20	
		VIII	8	—	—	—	—	—	12	20	

IDC: Inter-Disciplinary Course	AEC: Ability Enhancement Course	RP: Research Project / Internship
SEC: Skill Enhancement Course	VAC: Value Added Course	VSC: Vocational Skill Course

A student opting for exit after first year will be awarded UG Certificate, if, in addition to 40C, s/he complete one vocational course of 4C during summer.

A student opting for exit after second year will be awarded UG Diploma, if, in addition to 80C, s/he complete one vocational course of 4C during summer.

A student can opt for B. Sc. (Hons with Res) if they have secured a minimum of 75% marks in the first six semesters (B. Sc.).

A student opting for B. Sc. (Hons.) will have to take Elective courses of 12 credits instead of Research Project.

Semester I (20 Credits)	Semester II (20 Credits)	Semester III (20 Credits)	Semester IV (20 Credits)
Mechanics PHY111(4C, LTP: 301) (Major 1)	Basic Electronics PHY121 (4C, LTP: 301) (Major 2)	Modern Physics PHY211 (4C, LTP: 310) (Major 3)	Optics PHY221 (4C, LTP: 301) (Major 5)
Minor (4C, LTP: xxx) (Minor 1)	Minor (4C, LTP: xxx) (Minor 2)	Electricity and Magnetism PHY212 (4C, LTP: 301) (Major 4)	Heat and Thermodynamics PHY222 (4C, LTP: 310) (Major 6)
IDC (3C, LTP: xxx) (IDC 1)	IDC (3C, LTP: xxx) (IDC 2)	Minor (4C, LTP: xxx) (Minor 3)	Mathematical Physics I PHY223 (4C, LTP: 310) (Major 7)
SEC (3C, LTP: xxx) (SEC 1)	SEC (3C, LTP: xxx) (SEC 2)	SEC (3C, LTP: xxx) (SEC 3)	Minor (4C, LTP: xxx) (Minor 4)
AEC (2C, LTP: xxx) (AEC 1)	AEC (2C, LTP: xxx) (AEC 2)	AEC (2C, LTP: xxx) (AEC 3)	AEC (2C, LTP: xxx) (AEC 4)
VAC (4C, LTP: xxx) (VAC 1)	VAC (4C, LTP: xxx) (VAC 2)	IDC (3C, LTP: xxx) (IDC 3)	Project/Internship PHY225 (2C) (Project/Internship)

Semester V (20 Credits)	Semester VI (20 Credits)	Semester VII (20 Credits)	Semester VIII (20 Credits)
Solid State Physics PHY311 (4C, LTP: 310) (Major 8)	Atomic and Nuclear Physics PHY321 (4C, LTP: 310) (Major 12)	Classical Mechanics PHY411 (4C, LTP: 310) (Major 16)	Project/Electives PHY420 (12C) (Research Project)
Electronics PHY312 (4C, LTP: 202) (Major 9)	Advanced Modern Physics PHY322 (4C, LTP: 310) (Major 13)	Quantum Mechanics PHY412 (4C, LTP: 310) (Major 17)	Statistical Mechanics PHY421 (4C, LTP: 310) (Major 19)
Mathematical Physics II PHY313 (4C, LTP: 310) (Major 10)	Numerical and Computational Method PHY323 (4C, LTP: 202) (Major 14)	Classical Electrodynamics PHY413 (4C, LTP: 310) (Major 18)	Condensed Matter Physics PHY422 (4C, LTP: 310) (Major 20)
Physics Lab I PHY314 (4C, LTP: 004) (Major 11)	Physics Lab II PHY324 (4C, LTP: 004) (Major 15)	Minor (4C, LTP: xxx) (Minor 7)	
Minor (4C, LTP: xxx) (Minor 5)	Minor (4C, LTP: xxx) (Minor 6)	Minor (4C, LTP: xxx) (Minor 8)	

PHY 111: MECHANICS

(Credits 4, L-T-P: 3-0-1)

Course Description:

The primary aim of this course is to impress upon the students that a lot about nature can be learnt by careful observation and experimentation. Aristotle discovered that earth is round by observing a ship moving away whose mast disappeared first. Galileo found that different masses fall to the ground at the same time by observing the oscillations of chandeliers on a windy Sunday in a church. The observation that objects on a smooth surface move farther tells us of the most important law of motion - the law of inertia. We can say Newton's laws of motion provide the starting point for the major enterprise we call now as physics. The course on mechanics teaches the students of inertial frames and of non-inertial frames. The latter gives rise to pseudo forces : centrifugal, coriolis etc. The students get a glimpse of the symmetry of space and how such symmetries give rise to conservation laws. They learn of linear momentum, angular momentum; rigid body motion, and small oscillations. This course provides the backdrop for all the courses that follow in all the subsequent semesters.

Prerequisites:

The basic knowledge of Physics and Mathematics (10+2 level)

Syllabus:

- Introduction of gradient, divergence and curl. Mechanics of a particle. Law of conservation of energy. Conservative and non-conservative forces. Work energy theorem. Force as gradient of potential energy. Stable and unstable equilibrium. Concept of central force. Kepler's laws of planetary motions. Solving two particle central force problem using concept of relative and center of mass coordinates.
- Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. Fly wheel motion. Motion of top, Coriolis force and Foucault's pendulum
- Vedanga Jyotisha (Calendar calculations, Time measurement, Motion of Sun and moon along the ecliptic). Aryabhatiya (connection with relative motion and inertial frames). Karanakutuhala (calculating planetary positions, timekeeping and forecasting eclipses in Ancient India), Goladhyaya (study of spherical astronomy).
- Experimental study and determination of acceleration due to gravity (Bar pendulum, Kater's pendulum, and free fall body), Spring constant using dynamic and static methods, Height of a building using Sextant, Coefficient of Friction, flywheel motion, etc.

Course Outcomes (CO):

At the end of this course, the students will be able to

- have a comprehensive understanding of the principles of conservation of energy and linear momentum in various mechanical systems. (CO-1)
- analyze the motion under central forces, including gravitational forces. (CO-2)
- develop proficiency in experimental techniques for studying mechanics. (CO-3)
- appreciate the knowledge and concepts of Mechanics in Ancient India. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	2	1
CO-2	3	3	3	3	2	1
CO-3	3	3	3	3	2	1
CO-4	3	1	3	2	3	1

Text Books:

- Mechanics, D.S. Mathur. *S Chand & Co Ltd, India*,.
- Physics for scientists and engineers with modern physics, Raymond A. Serway and John W. Jewett. Cengage, India.
- Fundamentals of physics. Resnick, Halliday and Walker, Wiley, India.
- Schaum's outline of vector analysis. Murray R. Spiegel, McGraw Hill education, India.
- *The Feynman lectures on physics* Vol. 1. R.P. Feynman, R. B. Leighton and M. Sands, Pearson education, India.
- *Berkeley physics course: mechanics* Vol.1. C. Kittel, W. Knight, et.al., McGraw Hill education.
- Mechanics, Waves and Thermodynamics: An Example-based Approach. Sudhir Ranjan Jain, Cambridge University Press.
- A. Gosh, History of Science in India (Volume-I Part-II Astronomy), the national academy of science, India & the Ramkrishna mission institute of culture, 2014.

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. Students can opt for 3 (without lab) or 4 (including lab) credits of the course. The CIA-1 will be in the form of a written examination. The CIA-2 for 4 credits will be based on the performance in the lab in the form of a viva-voce, lab record etc. The CIA-2 for 3 credits will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY121: BASIC ELECTRONICS

(Credits 4, L-T-P: 3-0-1)

Course Description:

This course introduces the operation of the principal semiconductor devices: diodes, and bipolar junction transistors (BJTs). The detailed analysis related to diode and BJT circuits will be covered. The second half of the course deals with digital electronics and electronic instrumentation. The number system, their interconversions, Boolean logic theorems, and basic digital logic devices will be covered. In addition to this, the course also covers different bridges used in electronic/electrical parameters measurements.

Prerequisites:

The basic knowledge of Physics and Mathematics (10+2 level).

Syllabus:

Diodes:

Classification of solids, Energy bands in intrinsic and extrinsic silicon; Carrier transport in semiconductor, drift current, mobility and resistivity; Majority and minority carrier, Generation and recombination of carriers; PN junction, Zener Diode, Avalanche and Zener Breakdown, Simple diode circuits: rectifiers, Half wave, full wave and bridge rectifier, Voltage regulator.

Transistors:

BJT construction and characteristics, Configuration of transistors: Common Emitter (CE), Common Base (CB) and Common Collector configurations, Relation between α , β , and γ , Leakage current in Transistor, Thermal runaway, DC and AC load line analysis, Q point.

Digital Electronics:

Binary Numbers, Decimal to Binary and Binary to Decimal Conversion, BCD, Octal and Hexadecimal numbers, Negative numbers representation, 1's, 2's, Complements, Logic gates including Universal Gates, BCD codes, Excess-3 code, Gray code, Hamming code. Boolean Algebra, Basic Theorems and properties of Boolean Algebra, Boolean Functions, Minimization of Boolean Function, Ex-OR functions, Adder, Subtractor.

Experimental Electronics:

Experimental determination of resistance (Carey Foster bridge), Capacitance (De Sauty's bridge), and Self-inductance (Anderson's bridge) using different bridges. I-V characteristics of p-n junction diode and Transistor, Construction of Half Wave and Full Wave rectifier, Half adder and subtractor, Construction of basic logic gates using ICs.

Course Outcomes (CO):

- The students will learn the operation of diodes and transistors and their basic applications in electronic devices. (CO-1)
- The students can understand the number system and their interconversions. (CO-2)
- They will understand about digital electronics. They will get insights on digital logics theorems and basic combinational logic devices. (CO-3)
- They will develop understanding about the basic electronic instrumentation. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	3	1	1	1
CO-2	3	1	2	1	1	1
CO-3	3	1	3	1	1	1
CO-4	3	1	3	1	1	1

Text Books:

- Semiconductor Physics and Devices by Donald A. Neamen (4th Edition).
- Basic Electronics by B L Thereja, S Chand & Co ltd, India.
- Principal of Electronics by V.K. Mehta, S Chand & Co ltd, India.
- Semiconductor Physics and Devices by Donald A. Neamen (4th Edition).
- Basic Electronics by B L Thereja, S Chand & Co ltd, India.
- Electronic Devices and Circuit Theory by Boylestad / Nashelsky, Pearson Education India.

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. Students can opt for 3 (without lab) or 4 (including lab) credits of the course. The CIA-1 will be in the form of a written examination. The CIA-2 for 4 credits will be based on the performance in the lab in the form of a viva-voce, lab record etc. The CIA-2 for 3 credits will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY211: MODERN PHYSICS

(Credits 4, L-T-P: 3-1-0)

Course description:

Modern Physics usually refers to the developments of physics (e.g, quantum mechanics, atomic and nuclear physics, particle physics and cosmology, special theory of relativity) from the beginning of 20th century which provide fundamentally different prescriptions than long standing Newtonian Physics. This course introduces the basic concepts and descriptions of broad topics in physics. It discusses the basic formulation and consequences of the special theory of relativity. With the basic introduction of elementary quantum mechanics, this course discusses the quantization of atomic spectra, shape, size and radioactivity nucleus.

Prerequisites:

The basic knowledge of Physics and Mathematics (10+2 level).

Syllabus:

• Theory of Relativity:

Michelson-Morley experiment, Einstein's postulates, Lorentz transformation equations, Length contraction and time dilation, Experimental verification of time dilation, Relativistic addition of velocities, Relativistic kinetic energy, Relativity of mass, Mass energy equivalence, Momentum energy relations, Doppler effect in relativity, The general theory of relativity, Predictions of General relativity, Photons and gravity, Gravitational red shift.

• Atomic physics:

Rutherford's experiments on scattering of particles, Problems with Rutherford model-instability of atoms and observation of discrete atomic spectra, Bohr's quantization rule and atomic stability, hydrogen like atoms and their spectra, Effect of nuclear motion on atomic spectra, Bohr's correspondence principle, Drawbacks of Bohr's atomic model, Sommerfeld's relativistic atom model, The vector atom model, Quantum numbers associated with the vector atom model, Stern Gerlach experiment.

• Origin of quantum physics:

Planck's quantum theory, Photoelectric effect and Compton scattering, de Broglie hypothesis and matter waves, Wave-particle duality, Davisson-Germer experiment, G. P. Thomson experiment, Heisenberg uncertainty principle and its applications, Two slit interference experiment with photons, atoms & particles, linear superposition principle as a consequence, Matter waves and wave amplitude, Schrodinger equation for non-relativistic particles, Momentum and Energy operators; stationary states, physical interpretation of wave function, probabilities and normalization.

• Elementary nuclear physics:

Size and structure of atomic nucleus and its relation with atomic weight, Impossibility of an electron being in nucleus. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy, Radioactivity decay, stability of nucleus, Laws of radioactive decay, Mean life and half-life.

Course Outcomes (CO):

At the end of this course, the students will learn about:

- Basics of Special theory of relativity. (CO-1)
- The stability of atoms and different quantization laws. (CO-2)
- Elementary Quantum Mechanics. (CO-3)
- The size and shape of the nucleus. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	3	3
CO-2	3	3	3	1	1	1
CO-3	3	3	3	1	1	1
CO-4	3	3	3	1	1	1

Text Books:

- Concepts of Modern Physics. Arthur Beiser, McGraw Hill education, India.
- Modern Physics. R.A. Serway, C.J. Moses, and C.A. Moyer, Cengage Learning India.
- The *Feynman lectures on physics* vol. 3. R.P. Feynman, R. B. Leighton and M. Sands, Pearson education, India.
- *Berkeley Physics Course: Quantum Physics* Vol.4. E.H. Wichman, McGraw Hill education, India.
- Six Ideas That Shaped Physics, Unit Q: Particles Behave Like Waves. Thomas A. Moore, McGraw Hill education, India.

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY212: ELECTRICITY AND MAGNETISM

(Credits 4, L-T-P: 3-0-1)

Course description:

This course introduces electrical and magnetic phenomena in nature, including the concepts of electric and magnetic fields, the application of Gauss' Law, electric potential, Ampere's law, hysteresis loop, electromagnetic induction, eddy current and resonance in electric circuits having capacitive and inductive components.

Prerequisites:

The basic knowledge of Physics and Mathematics (10+2 level).

Syllabus:

● Electric Field and Potential:

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. Electrostatic energy of the system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor.

● Dielectric Properties of Matter:

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

● Magnetic Field:

Magnetic force between current elements and definition of Magnetic Field B . Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B : curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. Magnetic Properties of Matter: Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B , H , M . Ferromagnetism. B - H curve and hysteresis.

● Electromagnetic Phenomena and Circuit Analysis:

Experimental study and verification of the Faraday's law of induction, Series and parallel LCR circuits, Measurement of mutual inductance by Ballistic Galvanometer, Measurement of high resistance by leakage method, self inductance by Rayleigh's method, experimental verification of Bio Savart law.

Course Outcomes (CO):

At the end of this course, the students will be able to:

- understand the concept of electric field and electric flux, and apply Gauss' Law to analyze charge distributions with various symmetries such as spherical, cylindrical, and planar. (CO-1)
- develop an understanding of dielectric properties of matter. (CO-2)
- develop practical skills in circuit analysis and electromagnetic phenomena, including the application of fundamental principles to real-world scenarios. (CO-3)
- interpretation of experimental results in the context of electromagnetic theory. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	3	3	3	3
CO-2	3	1	3	3	3	3
CO-3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3

Text Books:

- Introduction to Electrodynamics, D. J. Griffiths. Pearson Education India.
- The *Feynman lectures on physics* Vol. 2. R.P. Feynman, R. B. Leighton and M. Sands, Pearson education, India.
- Electricity and Magnetism, Edward M. Purcell and David J. Morin. Cambridge University Press.
- Sears and Zemansky's University Physics: Electricity and Magnetism, H. D. Young and R. A. Freedman. Pearson Education India.

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. Students can opt for 3 (without lab) or 4 (including lab) credits of the course. The CIA-1 will be in the form of a written examination. The CIA-2 for 4 credits will be based on the performance in the lab in the form of a viva-voce, lab record etc. The CIA-2 for 3 credits will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY221: OPTICS (Credits 4, L-T-P: 3-0-1)

Course description:

This course first introduces the wave nature of light and fundamental laws of light propagation. After that it covers the interference and diffraction phenomenon using the light wave with different optical instruments. At the end it discusses the orientation of electric field vectors such as linear, circular and elliptical orientations and their realization using the wave plates.

Prerequisites:

The basic knowledge of Physics and Mathematics (10+2 level).

Syllabus:

● Interference:

Huygens' Principle, laws of reflection and refraction. Temporal and Spatial Coherence. *Division of wavefront*: Young's double slit experiment, Lloyd's mirror and Fresnel Biprism. Phase change on reflection. *Division of amplitude*: Interference in thin films (parallel and wedge-shaped films), Fringes of equal inclination, Fringes of equal thickness, Newton's Rings, Interferometer: Michelson interferometer and Fabry - Perot interferometer.

● Diffraction:

Fraunhofer Diffraction: Single slit, Rectangular and Circular aperture, Double slit, Multiple slits, Diffraction grating and its Resolving power. *Fresnel Diffraction*: Fresnel's assumptions. Fresnel's Half - period zones for plane waves. Explanation of rectilinear propagation of light. Theory of a zone plate and its multiple foci. Fresnel's integral, Cornu's spiral and its applications. Diffraction at straight edge and a slit.

● Polarization:

Types of polarization: Linear, circular, elliptical polarized light; Malus's law, Birefringence, Retarders: Quarter wave plate and Half wave plates

● Experimental Techniques of Optics:

Experimental determination of the radius of curvature of the given plano-convex lens using Newton's Rings, wavelength of sodium light by using Fresnel's Bi Prism, wavelength of laser light using single slit Laser Diffraction, Cauchy's constants, wavelength of mercury lines, verification of Malus law, numerical aperture of a multi-mode optical fiber, Brewster angle, intensity distribution by double slit laser diffraction, birefringence measurement by using Babinet compensator

Course Outcomes (CO):

At the end of this course, the students will be able to:

- understand basic principles of wave nature of light and its propagation. (CO-1)
- understand working principles of different optical instruments for the generation of interference and diffraction patterns. (CO-2)
- understand working principles of different optical wave-plates viz. quarter and half wave plates and their applications for the generation of different polarized light. (CO-3)
- develop comprehensive proficiency in experimental techniques in optics. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	1	1
CO-2	3	3	3	3	1	1
CO-3	3	3	3	3	1	1
CO-4	3	3	3	3	3	3

Text Books:

- Principles of Optics, Max Born and Emil Wolf, Cambridge University Press, 7th Edition, 1999.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, McGraw Hill education, 4th Ed, 2011.
- Optics, Ajoy Ghatak, McGraw Hill education, 3rd Edition, 2005.
- Optical Interferometry, P. Hariharan, Academic Press, 2nd Edition, 2003
- Optics, Eugene Hecht and A R Ganesan, Pearson Education, 5th Edition, 2019

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. Students can opt for 3 (without lab) or 4 (including lab) credits of the course. The CIA-1 will be in the form of a written examination. The CIA-2 for 4 credits will be based on the performance in the lab in the form of a viva-voce, lab record etc. The CIA-2 for 3 credits will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY222: HEAT AND THERMODYNAMICS

(Credits 4, L-T-P: 3-1-0)

Course description:

Thermodynamics was born when Nicolaus Leonard Sadi Carnot discovered that heat must fall from hot to cold to produce work. We call this now, the second law of thermodynamics; much later Benjamin Thompson, von Mayer, and Prescott James Joule established mechanical equivalence of heat and this led to the formulation of the first law of thermodynamics; Then came Rudolf Clausius who invented entropy to correctly capture the irreversibility inherent in the behavior of thermodynamic systems. This course will describe the exciting developments in the subjects of heat and thermodynamics and prepare the students to take off into the larger enterprise we call statistical mechanics.

Prerequisites:

The basic knowledge of Physics and Mathematics (10+2 level).

Syllabus:

- **Zeroth and First Law of Thermodynamics:**

Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law & Concept of Temperature, Work & Heat, First Law and its differential form, Internal Energy, First Law & various processes, Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient.

- **Second and Third Laws of Thermodynamics:**

Reversible and Irreversible process. Conversion of Work into Heat and vice versa. Heat Engines. Carnot's Cycle and engine. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics. Carnot's Theorem. Entropy, Clausius Theorem. Clausius Inequality, Entropy of a perfect gas, Entropy Changes in Reversible and Irreversible processes. Unattainability of Absolute Zero.

- **Thermodynamic Relations and Their Applications:**

Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Magnetic Work, Cooling due to adiabatic demagnetization, Derivation of Maxwell's thermodynamic Relations and their applications, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Value of $C_p - C_v$, (3) TdS Equations, (4) Energy equations. First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations,

- **Ideal and Real Gases:**

Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas. Law of Equipartition of Energy. Specific heats of Gases. Mean Free Path. Transport Phenomenon in Ideal Gases. Behavior of Real Gases: Deviations from the Ideal Gas Equation. Andrew's Experiments on CO_2 Gas. Virial Equation. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. van der Waals Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and van der Waals Gases. Temperature of Inversion. Joule-Thomson Cooling. Liquefaction of gases.

Course Outcomes (CO):

After attending this course, the students will

- learn that heat and work are two methods by which a thermodynamic system transacts energy with another thermodynamic system or with the surroundings. (CO-1)
- understand laws of thermodynamics and how they lead to a thermodynamic property. (CO-2)
- learn formulation of thermodynamics based on energy, entropy, free energy, enthalpy etc. (CO-3)
- apply the concepts of thermodynamics to solve a variety of problems, such as the expansion of gas; the efficiency of heat engines, refrigerators and heat pumps.(CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	3	3	3	3
CO-2	3	1	3	3	3	3
CO-3	3	1	3	3	3	3
CO-4	3	2	3	3	3	3

Text Books:

- Heat and Thermodynamics. M.W. Zemansky, Richard Dittman, McGraw Hill education.
- Thermal Physics. Stephen J. Blundell and Katherine M, Oxford University Press.
- Thermal Physics. S. Garg, R. Bansal and Ghosh, 2nd Edition, McGraw Hill education.
- Heat Thermodynamics and Statistical Physics. Brij Lal & Submhnranayam, S. Chand Publications.
- Thermodynamics and Statistical Mechanics. A. Sommerfeld, Levant Books.
- Mechanics, Waves and Thermodynamics: An Example-based Approach. Sudhir Ranjan Jain, Cambridge University Press.

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY223: MATHEMATICAL PHYSICS I

(Credits 4, L-T-P: 3-1-0)

Course description:

Mathematics and Physics are very closely linked subjects. Physicists need mathematical equations to describe the relationships between physical objects and the forces that act on them. Mathematical physics attempts to apply rigorous mathematical ideas to solve problems inspired by physics. Mathematics provides the tools for physics and can also drive physical insights. It is often joked that to unify all of physics, superstring theory also encompasses all of mathematics. Mathematics is the indispensable language of physics.

Prerequisites:

The basic knowledge of Physics and Mathematics (10+2 level).

Syllabus:

• Vector Analysis:

Transformation properties of vectors; Differentiation and integration of vectors; Line integral, volume integral and surface integral involving vector fields; Gradient, divergence and curl of a vector field; Gauss' divergence theorem, Stokes' theorem, Green's theorem - application to simple problems; Orthogonal curvilinear coordinate systems, unit vectors in such systems, spherical and cylindrical coordinate systems.

• Matrices:

Hermitian adjoint and inverse of a matrix; Hermitian, orthogonal, and unitary matrices; Eigenvalue and eigenvector (for both degenerate and non-degenerate cases); Similarity transformation; diagonalisation of real symmetric matrices.

• Ordinary Differential equations

Differential equations and mathematical models, General, Particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equations and Bernoulli's equation, special integrating factors and transformations.

• Special Functions Differential Equations:

Solution of second order linear differential equations with constant coefficients and variable coefficients by Frobenius' method (singularity analysis not required); Solution of Legendre and Hermite equations about $x=0$; Legendre and Hermite polynomials - orthonormality properties.

Course Outcomes (CO):

After going through the course, the students will be able to

- to solve complex mathematical problems using advanced techniques. (CO-1)
- apply vector analysis techniques to solve problems involving transformations, differentiation, and integration of vector fields. (CO-2)
- solve ordinary differential equations (ODEs) and apply them to mathematical models, including identifying different types of solutions. (CO-3)
- Demonstrate proficiency in problem-solving, mathematical modeling, and analytical reasoning, essential for further study or professional work in mathematics and related fields. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	2	3	3	2
CO-2	2	3	2	3	3	2
CO-3	2	2	3	2	3	2
CO-4	2	1	1	2	2	2

Text Books:

- Mathematical Methods in the Physical Sciences, Boas, Mary, Wiley India, 3rd edition, 2006.
- Mathematical Methods for Physics and Engineering. Ken Riley, Cambridge University Press India , 3rd edition, 2018.
- George Arfken, Mathematical methods for Physicists, Academic Press, 7th edition, 2012.
- Mathematical Physics, Rajput B S., Pragati Prakashan, 2017.
- R. K. Jain and S. R. K. Iyengar. Advanced engineering mathematics, 7th edition, New age international.

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY311: SOLID STATE PHYSICS

(Credits 4, L-T-P: 3-1-0)

Course description:

This course provides a comprehensive understanding of the fundamental principles governing the structure and properties of crystalline materials. It covers topics ranging from crystal structure and lattice dynamics to band theory of solids and dielectric/magnetic properties of matter. This course integrates theoretical concepts with practical applications providing students with a solid foundation in solid-state physics and its relevance to modern technologies and materials science.

Prerequisites:

Knowledge of Physics courses upto 5.0 level.

Syllabus:

• Crystal Structure

Crystal Structure Single crystals and polycrystalline forms, Lattice, Basis and crystal structure, Translational symmetry and basis vectors, Unit cell (primitive and nonprimitive), Two dimensional point groups and Bravais lattices, Miller indices, SC, BCC and Sodium Chloride structures, closed packed structures (FCC and HCP). Reciprocal lattice, X-rays diffraction, Bragg's law, Laue and powder methods of X-rays diffraction.

• Lattice Dynamics

Lattice vibrations, Monoatomic lattice, Phonons, Free electron theory of metals, limitations of Lorentz Drude theory, Sommerfeld theory, Specific heat and paramagnetism of free electrons, Dulong and Petit's law, Departure of the law at low temperatures, Einstein's theory of specific heat and its limitations, Debye's theory of specific heat of solids.

• Band theory of Solids

Motion of an electron in periodic potential (one dimensional), Results of Kronig-Penny model, Distinction between conductors, Semiconductors and Insulators, Intrinsic and Extrinsic semiconductors, Effective mass of electron, Concept of holes.

• Dielectric and Magnetic properties of Matter

Electric Susceptibility, Polarizability, Clausius Mosotti Equation, Classical Theory of Electric Polarizability, Normal and Anomalous Dispersion, Cauchy and Sellmeier relations, Langevin-Debye equation, Complex Dielectric Constant, Dia, para and ferro-magnetic properties of solids. Langevin's theory of diamagnetism and paramagnetism. Quantum theory of paramagnetism, Curie's law, Ferromagnetism: spontaneous magnetization and domain structure; temperature dependence of spontaneous magnetisation; Curie-Weiss law, explanation of hysteresis.

Course Outcomes (CO):

At the end of this course, the students will be able to

- understand the fundamental principles of crystal structure and its significance in determining the properties of materials. (CO-1)
- understand the lattice vibrations, phonons, and the free electron theory of metals. (CO-2)
- apply the concepts of band theory to classify materials as conductors, semiconductors, or insulators (CO-3)
- understand dielectric and magnetic properties of matter. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	1	2	1	1
CO-2	3	2	1	3	2	2
CO-3	3	2	1	2	2	2
CO-4	3	2	1	3	2	2

Text books

- Introduction to Solid State Physics, C. Kittel, John Wiley & Sons Inc.
- Elementary Solid State Physics – M. Ali Omar, Pearson Education
- Solid State Physics – A. J. Dekker, Mc. Millan
- Introduction to Solids, L. V. Azaroff, Mc Graw Hill
- Fundamental University Physics, Marcelo Alonso and Edward J. Finn, Addison-Wesley series in Physics
- Solid State Physics, Ashcroft and Mermin, Cengage Learning

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY312: ELECTRONICS

(Credits 4, L-T-P: 2-0-2)

Course description:

This course has been designed keeping in mind the importance of ever increasing usage of electronic devices in our day-to-day life. The course will impart knowledge of the fundamental components and parts used in the electronic devices. This is an ability enhancement (AE) or skill development (SD) course to cater the need of skill India, a flagship program of the Government of India.

Prerequisites:

Knowledge of Physics courses upto 5.0 level.

Syllabus:

• Transistors:

Bipolar Junction transistor: transistor as an amplifier, stability factor, different gain stabilizing circuits, emitter follower, switching action of a transistor, multivibrators using transistors: a stable, monostable and bistable multivibrators.

• Amplifiers:

Differential amplifier: its structure and working, common mode- and differential-gain, common mode rejection ratio, Operational amplifier (OP-amp): OP-amp characteristics, inverting and non-inverting amplifiers, OP-amp feedback parameters, OP-amp applications including summer, subtractor, multiplier, divider, integrating and differential circuits, voltage follower, Instrumentation amplifier, log and antilog amplifiers, op-amp as comparator, Schmitt trigger, voltage to current and current to voltage conversions, filters using OP-amp.

• Boolean Algebra:

Boolean algebra, de-Morgan theorem, Karnaugh mapping, multiplexers, combinational and sequential circuits, flip-flops, Counters, Registers.

• Experimental techniques:

Experimental learning of Transistor as a feedback amplifier, Learning of various OP-amp applications, Learning of various Flip flops, Learning of counters, Learning of registers, Multiplexers and demultiplexers, Multivibrators using transistor and 555 timer IC, Learning operation of multimeter, digital oscilloscope etc. Eigenstates of the Schrodinger equation, time-evolution of wave-packets, quantum spin systems (ground state and finite-temperature properties).

Course Outcomes (CO):

At the end of this laboratory, the students will be

- Familiar about the concepts of components used in various electronic devices. (CO-1)
- Able to learn the basics of digital electronics which will be useful to them in understanding the concept behind digital world. (CO-2)
- Familiar with the theoretical and experimental understanding of workings of transistors and amplifiers. (CO-3)
- Able to have the experimental hands-on experience with various electronic circuits and digital electronic devices. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	2	2
CO-2	3	3	3	3	2	2
CO-3	3	3	3	3	2	3
CO-4	3	3	3	3	2	3

Text Books:

- Electronic Devices and Circuit theory, R. L. Boylestad, L. Nashelsky, Pearson publication
- Electronic Devices Electron flow version, T. L. Floyd, Pearson publication
- Principles of electronic materials and devices, S. O. Kasap, McGraw Hill publication
- Electronic Principles, A. P. Malvino, McGraw Hill
- Physics of Semiconductor Devices, S. M. Sze, Wiley publication
- Digital Principles and Applications, A. P. Malvino, D. P. Leach, McGraw Hill publication
- Digital fundamentals, T. L. Floyd, Pearson publication
- Digital Electronics: Principles and Integrated Circuits, A. K. Maini, Wiley publication

Assessment Method:

The course consists of two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. First CIA will be in the form of written examination while the second CIA will be in the form of a surprise test, quiz or classroom presentation as decided by the course instructor. The ESE will be lab based examination.

PHY313: MATHEMATICAL PHYSICS II

(Credits 4, L-T-P: 3-1-0)

Course description:

Mathematics, as the saying goes, is the queen of all sciences. For a physicist, mathematics provides his mother tongue. Of late, we have realized that thorough knowledge of mathematics is a must not only in physics discipline but also in all other disciplines like chemistry, biology, economics *etc.* The mathematical physics course is designed so that a student learns mathematics and acquires enough practice and skills to apply what he has learnt to problems in all other subjects in physical sciences. More importantly this course trains a student into a mathematical way of thinking involving rigor and precision.

Prerequisites:

Knowledge of Physics courses upto 5.0 level.

Syllabus:

● Brief Introduction to Vectors and Tensors:

Review of the properties of scalars, vectors and tensors, vector multiplication and geometrical Applications, Linear independence and orthogonality of vectors, Equations of lines and planes, Kronecker delta symbol, Levi-Civita symbol, Physical interpretation of 'div' and 'curl', Integrals over Fields, Coordinate transformations, simple applications of tensors in non-relativistic physics, Ohm's law in an anisotropic medium, Angular momentum and the inertia tensor, Transformation properties of tensors, electrical conductivity, tensors, stress and strain tensors, generalized Hook's law.

● Vector Spaces and Matrices:

Linear vector spaces, Gram-Schmidt orthogonalisation procedure. Linear operators. Matrix representation. Solution of linear equations, Linear transformations, Eigenvalues and eigenvectors of matrices. Diagonalization of matrices, Principal axis transformation, Functions of matrices.

● Analysis of Complex Variables:

Geometrical representation of complex numbers, Functions of complex variables, Cauchy-Riemann equations, Properties of analytical functions, Contours in complex plane, Integration in complex plane, Cauchy theorem, Cauchy integral representation, Taylor series representation, Isolated and essential singular points, Branch Point and branch Cut, Laurent expansion theorem, Poles, Residues at an isolated singular point, Cauchy residue theorem, Application of residue theorem to the evaluation of definite integrals and the summation of infinite series.

● Ordinary, Partial Differential Equation and Frobenius Method & Special Functions:

Ordinary differential equations, separation of variables, Laplace and Poisson's equation in cartesian, cylindrical and spherical polar coordinates, wave equations, heat equation and diffusion equation, boundary value problems. Singular points of second order linear differential equations and their importance, Frobenius method, Legendre differential equations, properties of Legendre polynomials, orthogonality, recurrence relations, Rodrigues formula, generating function. Bessel functions of first and second kind, Hermite and Laguerre differential equations and their generating functions.

Course Outcomes (CO):

At the end of this course, the students will be able to

- To solve eigenvalue problems and to learn the diagonalization of matrices in several areas of physics, singularities and poles, residues, complex integrals. (CO-1)
- To define continuity and differentiability for complex functions and to study the Taylor and Laurent series expansions (CO-2)
- To use the concepts of singularities, poles and residues to solve the integrals appearing in physics, engineering and mathematics. (CO-3)
- Understand the significance of singular points in second-order linear differential equations. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	3	3	2	2
CO-2	3	1	2	3	2	2
CO-3	3	1	3	3	2	2
CO-4	3	1	3	3	1	1

Text Books:

- K. F. Riley, M. P. Hobson and S. J. Bence. Mathematical Methods for Physics and Engineering. Cambridge University Press India.
- George B. Arfken, H J. Weber and F E. Harris. Mathematical Methods for Physicists, Academic Press
- Mary Boas. Mathematical Methods in the Physical Sciences, 3rd edition, Wiley India.
- V. Balakrishnan, Mathematical Physics with Applications, Problems and Solutions, Ane Books.
- Robert W. Fuller, The mathematics of classical and quantum physics, Dover publications.
- R. K. Jain and S. R. K. Iyengar. Advanced engineering mathematics, 5th edition, New age international.
- A. W. Joshi. Elements of group theory for physicists, New age international.
- A. W. Joshi. Matrices and Tensors, New Age International, Daryaganj, New Delhi.
- P K. Chattopadhyay, Mathematical Physics, 3rd edition, New Age International, New Delhi.
- Jon Mathews and Robert L. Walker. Mathematical Methods of Physics, Pearson Education.

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY314: PHYSICS LAB I
(Credits 4, L-T-P: 0-0-4)

Course description:

The aim of this laboratory course is to make the students understand the usage of basic laws and theories to determine various properties of the materials and gain knowledge regarding the underlying Physics to pursue solutions for various problems.

Prerequisites:

Knowledge of Physics courses upto 5.0 level.

Syllabus:

1. Millikan Oil drop experiment
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine the wavelength of H-alpha emission line of Hydrogen atom
4. To determine value of Planck's constant using LEDs of at least 4 different colours
5. e/m by Thomson's method
6. Heisenberg Uncertainty principle
7. Verification of the Faraday's law of induction
8. To verify discrete atomic level using the Frank-Hertz experiment
9. Biot-Savart law
10. Speed of light using Hertz experiment
11. k/e ratio measurement

Course Outcomes (CO):

At the end of this laboratory course, the students will be capable of

- handling sophisticated instruments besides learning the Physics concepts behind these experiments. (CO-1)
- develop skills in experimental techniques, data acquisition, and error analysis. (CO-2)
- explore the phenomenon of photoelectric effect and uncertainty principle. (CO-3)
- determine the Planck's constant and discrete atomic levels. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	3	1
CO-2	3	3	2	2	3	2
CO-3	3	3	2	2	3	2
CO-4	3	3	3	2	2	2

Text Books:

- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced Practical Physics for Students, B.L. Worsnop, H.T. Flint
- BSc Practical Physics, GeetaSanon, R. Chand & Co
- Advanced Practical Physics vol.1-SP Singh (Pragati prakashan).

Assessment Method:

There are continuous internal assessment (CIA) and one end semester examination (ESE). The CIA would be of 40 marks and the ESE would be of 60 marks. The CIA will be based on the performance in the lab in the form of a viva-voce, lab record etc.

PHY321: ATOMIC AND NUCLEAR PHYSICS

(Credits 4, L-T-P: 3-1-0)

Course description:

The course is designed to develop the basic concepts and theories of nuclear physics as well as an understanding of the applications of nuclear science in all the fields of sciences.

Prerequisites:

Knowledge of Physics courses upto 5.0 level.

Syllabus:

● Atomic structure and spectrum:

Atomic structure and atomic spectra, Thomson's model, Rutherford's model, Derivation of Rutherford's scattering formula and the inadequacies in Rutherford's model, Concept of stability of atom, Bohr's atomic model and Bohr's postulates, Electron orbits, Atomic excitation, Energy levels, Lyman, Balmer, Paschen, Bracket and Pfund series, Rydberg constant, Effect of nuclear motion, Franck-Hertz experiment, Ritz combination principle, Comparison of H and He⁺ spectra, Wilson-Sommerfeld quantization rules, Bohr's correspondence principle

● Atomic physics and angular momentum:

Intrinsic spin, Magnetic moment, Bohr Magneton, Larmor Precession, Energy levels and spectroscopic terms, Total angular momentum, Vector model of atom: concepts of L-S coupling, J-J coupling, Stern-Gerlach experiment, Spin orbit coupling, Relativistic correction, Fine structure, Lamb shift, Normal and anomalous Zeeman effects, Paschen-Back effect

● Nuclear physics:

Nuclear Physics: Size, Shape, Charge distribution, Spin and parity, Magnetic moments, Nuclear binding energy, Plot of binding energy per nucleon against mass number, Magic numbers, Semi-empirical mass formula, Liquid drop model and its shortcomings, Fermi gas model of nucleus, Shell model, Nuclear spin and parity estimations, Collective model, Nuclear accelerator and detector

● Radioactive decays:

Natural and artificial radioactivity, Units of radioactivity, Radioactive decay laws and radioactive dating, Radioactive growth and decay, Radioactive series, Nuclear decay: Alpha decay, Geiger-Nuttall law, Alpha-particle spectrum, Disintegration energy, Beta decay, Beta-ray spectrum, Neutrino hypothesis, Selection rules, Parity non-conservation in beta decay, Nuclear fission and fusion, Gamma rays

Course Outcomes (CO):

At the end of this course, the students will be able to

- Understand the fundamental knowledge of atoms, nucleus and their properties. (CO-1)
- Understand the effects of external magnetic fields in atomic energy levels, eg, SOC, Zeeman effect, L-S & J-J coupling. (CO-2)
- Learn about the radiation hazards, peaceful use of nuclear energy and carbon dating for fossil's age determination. (CO-3)
- Go into higher studies in this field and may get employment opportunities in radiology, medical fields, and research institutes such as BARC, IPR etc. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	3	2	1	2
CO-2	3	2	3	2	1	2
CO-3	3	3	3	3	2	3
CO-4	3	3	3	3	3	3

Text Books:

- Introductory nuclear Physics, Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics, Bernard L.Cohen.(Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000)

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor

PHY322: ADVANCED MODERN PHYSICS
(Credits 4, L-T-P: 3-1-0)

Course description:

This course offers intermediate topics of nonclassical physics covering Quantum Mechanics, Solid-State Physics, and Particle Physics.

Prerequisites:

Knowledge of Physics courses upto 5.0 level.

Syllabus:

● **Quantum Mechanics:**

Wave Packets, The Motion of a Wave Packet, Origin of the Schrodinger Equation, Time-independed and time-dependent Schrodinger equations, Applications of the Schrodinger Equation, 1-d quantum problems: Particle in a box, Simple Harmonic Oscillator, Steps and Barriers, Quantum Tunneling, Operators, their eigenvalues and eigenvectors, Concept of measurement in quantum mechanics.

● **Solid-State Physics:**

Crystal Structures, 3d-crystal structures: SCC, BCC, FCC. The Heat Capacity of Solids, Electrons in Metals, Band Theory of Solids, Superconductivity, Intrinsic and Impurity Semiconductors, Semiconductor Devices, Magnetic Materials.

● **Particle Physics:**

The Four Basic Forces, Classifying Particles, Conservation Laws, Particle Interactions and Decays, Energy and Momentum in Particle Decays, Energy and Momentum in Particle Reactions, The Quark Structure of Mesons and Baryons, The Standard Model.

Course Outcomes (CO):

At the end of this course, the students will be able to

- Learn about the basic aspects of quantum mechanics. (CO-1)
- Understand the concept of measurement and probabilistic nature of quantum physics. (CO-2)
- Learn about the basic aspects of solid state physics including crystal structures. (CO-3)
- Learn about the concepts of fundamental forces acting in the universe and basics of particle physics. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	3	3	1	2
CO-2	3	1	2	3	1	2
CO-3	3	1	2	3	1	2
CO-4	3	1	2	3	1	2

Text Books:

- Modern Physics (3rd Edition), Kenneth S. Krane, Wiley (2012).
- Quantum Physics: Of Atoms, Molecules, Solids, Nuclei And Particles (2nd Edition), Robert Eisberg and Robert Resnick, Wiley (1985).
- Concepts of Modern Physics (6th Edition), Arthur Beiser, McGraw-Hill (2002).
- Modern Physics (3rd Edition), Raymond A. Serway, Clement J. Moses, and Curt A. Moyer, Cengage (2004).
- The Feynman Lectures on Physics, Vol. III, Richard P. Feynman, Robert B. Leighton, and Matthew Sands, Addison Wesley (1971).
- Quantum Physics (Berkeley Physics Course, Volume 4, 2nd Edition), Eyvind H. Wichmann, McGraw-Hill (1971).
- Modern Physics (2nd Edition), Randy Harris, Pearson (2007).
- Introduction to Solid State Physics, Eighth Edition, Charles Kittel, Wiley (2012).
- Introductory Nuclear Physics, Kenneth S. Krane, Wiley (2008).
- Modern Physics for Scientists and Engineers, Fourth Edition, Stephen T. Thornton and Andrew Rex, Cengage Learning (2013).

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY323: NUMERICAL AND COMPUTATIONAL METHOD
(Credits 4, L-T-P: 2-0-2)

Course description:

To make the students learn essential aspects of a programming language, numerical techniques and their applications in a variety of Physics problems.

Prerequisites:

Knowledge of Physics courses upto 5.0 level.

Syllabus:

● **Root-finding and numerical integration:**

Root-finding methods: bisection method, Newton's method, Newton's method and shooting, steepest descent. Basic integration schemes, stochastic methods for multi-dimensional integrals.

● **Numerical solutions of differential equations:**

The Verlet method, Runge–Kutta methods, classical equation of motion, systems with chaotic dynamics.

● **Monte-Carlo simulations and Molecular Dynamics in statistical mechanics:**

The Metropolis algorithm for equilibrium statistical mechanics, studies of the phase transition in the Ising model of magnetism, cluster algorithms, molecular dynamics.

● **Numerical solutions of quantum mechanical problems:**

Eigenstates of the Schrodinger equation, time-evolution of wave-packets, quantum spin systems (ground state and finite-temperature properties).

Course Outcomes (CO):

At the end of this laboratory, the students will be

- proficient in employing various root-finding methods. (CO-1)
- capable of using numerical ideas in diverse areas such as biological systems, economics, and nonlinear dynamics. (CO-2)
- able to apply numerical techniques such as the Verlet method and Runge-Kutta methods to solve differential equations. (CO-3)
- capable of numerically solving quantum mechanical problems. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	2	2	1
CO-2	3	3	3	2	2	2
CO-3	3	2	3	2	3	3
CO-4	3	2	3	2	3	3

Text Books:

- Michael Metcalf, John Reid, and Malcolm Cohen, Modern Fortran Explained: Incorporating Fortran 2018, Oxford University Press.
- Bjarne Stroustrup, The C++ Programming Language (4th Edition), Addison-Wesley.
- John M. Stewart, Python for Scientists (2nd Edition), Cambridge University Press
- W. H. Press and S. A. Teukolsky, Numerical Recipes (3rd Edition), Cambridge University Press.
- Werner Krauth, Statistical Mechanics: Algorithms and Computations, Oxford University Press.
- J. M. Thijssen, Computational Physics (2nd Edition), Cambridge University Press.
- Joel Franklin, Computational Methods for Physics, Cambridge University Press.
- N. J. Giordano and H. Nakanishi, Computational Physics (2nd Edition), Addison-Wesley.
- R. H. Landau et al., Computational Physics: Problem Solving with Computers, Wiley-VCH.
- D. P. Landau and K. Binder, A Guide to Monte Carlo Simulations in Statistical Physics (4th edition), Cambridge University Press.

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be programming based in lab while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY324: PHYSICS LAB II
(Credits 4, L-T-P: 0-0-4)

Course description:

The aim of this laboratory course is to make the students perceive some of the fundamental laws of Physics through experiments and gain knowledge regarding the underlying Physics to pursue solutions for various problems. This course introduces some advanced experiments related to Optics, Condensed Matter, Atomic and Nuclear Physics.

Prerequisites:

Knowledge of Physics courses upto 5.0 level.

Syllabus:

1. Light Runner
 - a. To study the length dependence of attenuation in the given optical fiber at different wavelengths.
 - b. To determine the relationship between the laser current and output power and hence find out the threshold laser current.
 - c. To check the linearity between laser optical power and its monitor diode.
2. Measurement of magnetic susceptibility of paramagnetic solution by Quincke's method.
3. To investigate the attenuation of x-rays as a function of the absorber thickness and absorber material.
4. Solar (V-I)
 - a. To demonstrate the I-V and P-V characteristics of PV modules with varying radiation and temperature levels.
 - b. To demonstrate the I-V and P-V characteristics of series and parallel combination PV modules.
 - c. To demonstrate the working of diode as bypass diode and blocking diode.
5. To determine the wavelength of sodium light using Michelson Interferometer.
6. To determine the wavelength of the most intense spectral lines of Helium and calculation of Rydberg Constant.
7. To find the resistivity and energy band gap of silicon semiconductor using four probe method.
8. Study of Hall Effect in a semiconductor and determination of all its parameters

Course Outcomes (CO):

At the end of this laboratory course, the students will be capable of

- understand the principles and phenomena involved in various experimental setups in physics. (CO-1)
- apply theoretical knowledge to design, conduct, and analyze experiments in different areas of physics. (CO-2)
- demonstrate proficiency in using scientific instruments and techniques commonly employed in experimental physics. (CO-3)
- interpret experimental results, draw conclusions, and communicate findings effectively through written reports and oral presentations. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	3	3	3	3
CO-2	3	3	3	3	3	3
CO-3	3	3	3	3	3	3
CO-4	3	3	3	3	3	3

Text Books:

- A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced Practical Physics for Students, B.L. Worsnop, H.T. Flint
- BSc Practical Physics, GeetaSanon, R. Chand & Co.
- Advanced Practical Physics vol.1 – SP Singh (Pragati prakashan).

Assessment Method:

There are continuous internal assessment (CIA) and one end semester examination (ESE). The CIA would be of 40 marks and the ESE would be of 60 marks. The CIA will be based on the performance in the lab in the form of a viva-voce, lab record etc.

PHY411: CLASSICAL MECHANICS

(Credits 4, L-T-P: 3-1-0)

Course description:

How and why things move the way they do? For a long time, we believed that for an object to move we require an agent. For example, our ancestors told us that the sun's chariot was drawn by seven horses tied by snakes. However, now we know that things moving with a constant velocity are natural and do not require any external agent. We call it inertia. One needs the help of a force when one wants to change the velocity. Inertia is enshrined in the first law of Newton.

Prerequisites:

Knowledge of Physics courses upto 5.5 level.

Syllabus:

- **Lagrangian and Hamiltonian Formulations of Mechanics:**

Calculus of variations, Hamilton's principle of least action, Lagrange's equations of motion, conservation laws, systems with a single degree of freedom, rigid body dynamics, symmetrical top, Hamilton's equations of motion, phase plots, fixed points and their stabilities.

- **Two-Body Central Force Problem:**

Equation of motion and first integrals, classification of orbits, Kepler problem, scattering in the central force field.

- **Small Oscillations:**

Linearization of equations of motion, free vibrations and normal coordinates, forced oscillations.

- **Hamiltonian Mechanics and Chaos:**

Canonical transformations, Poisson brackets, Hamilton-Jacobi theory, action-angle variables, perturbation theory, integrable systems, introduction to chaotic dynamics.

Course Outcomes (CO):

This course will enable students to

- Understand the Lagrangian and Hamiltonian Formulations of Mechanics. (CO-1)
- Concepts of central force problems to analyze the motion of two-body systems. (CO-2)
- Analyze small oscillations and their properties. (CO-3)
- Understanding of Hamiltonian mechanics and chaos theory. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	3	3	1	1
CO-2	3	1	3	3	1	1
CO-3	3	1	2	2	1	1
CO-4	3	1	2	3	3	2

Text Books:

- Classical Mechanics, Herbert Goldstein, Poole Jr., Charles P., and John L. Safko, Pearson (2001).
- Mechanics (Course of Theoretical Physics), L. D. Landau and E. M. Lifshitz, Butterworth-Heinemann (1976).
- Introduction to Dynamics, I. C. Percival and D. Richards, Cambridge University Press (1983).
- Classical Dynamics: A Contemporary Approach, Eugene J. Saletan and Jorge V. José, Cambridge University Press (CUP) (1998).
- A Treatise on the Analytical Dynamics of Particles and Rigid Bodies (4th edition), E. T. Whittaker, CUP (1989).
- Mechanics: From Newton's Laws to Deterministic Chaos (6th Edition), Florian Scheck, Springer (2018).
- Theoretical Mechanics of Particles and Continua, Alexander L. Fetter and John Dirk Walecka, Dover (2003).
- Analytical Mechanics, Louis N. Hand and Janet D. Finch, CUP (1998).
- Classical. Mechanics, N. C. Rana and P. S. Joag, Tata-McGraw Hill(1994).
- Foundations of Classical Mechanics, P. C. Deshmukh, CUP (2019).

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY412: QUANTUM MECHANICS

(Credits 4, L-T-P: 3-1-0)

Course description:

In the beginning few years of the last century, it was realized that the well profound classical mechanics fails to explain many experimental outcomes. To overcome such limitations and difficulties, an alternative theory of what we call Quantum Mechanics was proposed. This theory is essential to study a variety of modern physics subjects such as atomic, molecular, nuclear, and particle physics. It has broad and rich applicability in condensed matter physics and also in chemistry.

Prerequisites:

Knowledge of Physics courses upto 5.5 level.

Syllabus:

- **Formalism and Postulates of Quantum Mechanics:**

Dirac notation, Hilbert space in context of quantum mechanics, Operators in quantum mechanics, Matrix representations, Eigenvalues and Eigenvectors, Discrete and continuous basis of Hilbert space with special reference to eigenvectors of position, momentum and energy operators.

Concepts of physical observables and measurements in quantum mechanics, Probabilistic outcome of measurements and determinate states, Compatible and non-compatible observables, Uncertainty relation.

- **Schrodinger Equation in time-independent potentials:**

One-dimensional problems: Particle in a box, Harmonic oscillator, Infinite and finite square wells, Three-dimensional problems: Central potentials, Spherical harmonics, Hydrogen atom, Two-particle systems: Distinguishable vs indistinguishable particles, Bosons and Fermions, Pauli exclusion principle.

- **Applications of quantum mechanics and Approximation Methods:**

Time-independent perturbation theory: non-degenerate and degenerate cases, Variational principle, WKB Approximation, Time-dependent perturbation theory, Scattering theory.

- **Theory of Angular Momentum:**

Angular momentum operators, eigenvalues and eigenstates, Orbital and Spin angular momenta, spin half and Pauli matrices, Addition of angular momenta and Clebsch-Gordon coefficients.

Course Outcomes (CO):

- Feel comfortable in the process of solving the quantum mechanical eigenvalue problems (CO-1).
- Digest the connection between measurement results and the uncertainty relation (CO-2).
- Appreciate the amazing power and surprises of quantum mechanics in problems like free particles and particles in a potential (CO-3).
- Recognize the applicability of angular momenta in several branches of physics (CO-4).

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	3	1	1	3
CO-2	3	1	3	2	2	3
CO-3	3	1	3	2	3	3
CO-4	3	1	3	3	3	3

Text Books:

- David J. Griffiths and Darrell F. Schroeter, Introduction to Quantum Mechanics.
- F. W. Byron and R. W. Fuller, The Mathematics of Classical and Quantum Physics, Dover.
- J. J. Sakurai, Modern Quantum Mechanics, Second Edition, Pearson.
- R. Shankar, Principles of Quantum Mechanics, Second Edition, Springer.
- E. Merzbacher, Quantum Mechanics, Third Edition, Wiley.
- K. Gottfried, Quantum Mechanics, Second Edition, Springer.
- A. Messiah, Quantum Mechanics (Vol. I & II), Dover Publications Inc.
- Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe, Quantum Mechanics (Vol. I & II), Wiley.
- Richard P. Feynman, The Feynman Lectures on Physics (Vol. III), Pearson.
- L. D. Landau and E.M. Lifshitz, Quantum Mechanics, Third Edition, Butterworth-Heinemann.

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY413: CLASSICAL ELECTRODYNAMICS

(Credits 4, L-T-P: 3-1-0)

Course description:

This course covers the basic principles and phenomenon involved of electric and magnetic fields and their combined time varying effects. The equations of Maxwell that condense elegantly the vast experimental findings of Michael Faraday, his predecessors, and contemporaries, on electricity and magnetism constitute the course on electrodynamics. Further, it covers the propagation of electromagnetic waves under different media such as dielectric, metal, etc. and study their behavior during reflection and refraction coefficients at the interface and waveguides. The invariance of Maxwell's equations under Lorentz transformation provided the key to the special theory of relativity of Albert Einstein.

Prerequisites:

Knowledge of Physics courses upto 5.5 level.

Syllabus:

● Review of Electrostatics and Magnetostatics:

Coulomb's law, concept of fields, electrostatic energy, Poisson and Laplace equations, formal solution for potential with image method and Green's function method, boundary value problems, multipole expansion, Biot-Savart law, differential equation for static magnetic field, vector potential, magnetic field from localized current distributions, Faraday's law of induction, energy densities of electric and magnetic fields.

● Maxwell's Equations:

Maxwell's equations in different mediums, Vector and Scalar potentials in electrodynamics, gauge invariance and gauge fixing, Coulomb and Lorenz gauges. Displacement current. Electromagnetic energy and momentum, Poynting Theorem. Conservation laws.

● Electromagnetic Waves:

Plane waves in a dielectric medium, reflection and refraction at dielectric interfaces. Fresnel's Formula, Change of phase on reflection, Polarization on reflection and Brewster's law, Total Internal reflection. Wave equation in conducting medium, reflection and transmission at metallic surface, skin effect and skin depth. Frequency dispersion in dielectrics and metals. Dielectric constant and anomalous dispersion. Wave propagation in one dimension, group velocity. Wave guides, propagation modes in waveguides, resonant modes in cavities. Dielectric waveguides.

● Radiation:

EM Field of a localized oscillating source. Fields and radiation in dipole and quadrupole approximations. Antenna; Radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula.

Course Outcomes (CO):

- The students will be capable of understanding the underlying Physics behind telecommunication. (CO-1)
- The students will be able to analyze different radiative systems such as electric dipole, magnetic dipole, electric quadrupole and their importance and dominance over each other. (CO-2)
- The students will have basic understanding of the covariant formulation of electrodynamics and the concept of retarded time for charges undergoing acceleration. (CO-3)
- Students will be prepared enough to understand advanced courses in relativistic quantum field theory. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	3	3	3	3
CO-2	3	2	3	3	3	3
CO-3	3	2	3	3	3	3
CO-4	3	2	3	3	3	3

Text Books:

- Classical Electrodynamics, by J.D. Jackson, Wiley India Pvt. Ltd (2007)
- Introduction to Electrodynamics, by D.J. Griffiths, Cambridge University Press, Fourth Edition (2017)
- Electromagnetic Fields and Waves, by P. Lorrain, and D. Corson, CBS Publishers (2003)
- Principles of Electromagnetics, by Matthew N. O. Sadiku, S.V. Kulkarni, Oxford University Press; Sixth edition
- Electromagnetic Waves, by R K Shevgaonkar, McGraw Hill Education; first Edition
- Foundations of Electromagnetic Theory, by J.R. Reitz, F.J. Milford and R.W. Christy, Addison Wesley Publisher; 4 edition (1992)

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY421: STATISTICAL MECHANICS

(Credits 4, L-T-P: 3-1-0)

Course description:

The time asymmetry in the behavior of macroscopic bodies is captured in thermodynamics by the property called entropy; we have the inevitable entropic arrow of time. Contrast this with the time reversal invariance of microscopic laws be it classical or quantum mechanics, or electrodynamics. In the synthesis of macroscopic objects from its microscopic ingredients when and how does time asymmetry emerge? Ludwig Eduard Boltzmann answered this question by interpreting entropy, completely in terms of probabilities. After all, irreversibility is natural to a probabilistic evolution. Thus was born the subject of statistical mechanics which developed quickly and acquired certain robustness with the work of Josiah Willard Gibbs, James Clerk Maxwell and Albert Einstein.

Prerequisites:

Knowledge of Physics courses upto 5.5 level.

Syllabus:

- **Brief review of Thermal Physics:**

Extensive and intensive variables, laws of thermodynamics, entropy and Gibbs paradox, Legendre transformation, thermodynamic potentials, chemical potential, Jacobian determinant, Maxwell's relations and their applications.

- **Statistical description of many-particle systems:**

Binomial, Gaussian, and Poisson distributions, central limit theorem. Phase space, Liouville's theorem. Microstates and macrostates, statistical ensemble, statistical postulates, probability calculations, accessible states, constraint, equilibrium, irreversibility.

- **Equilibrium statistical mechanics:**

Microcanonical ensemble. Canonical ensemble: Boltzmann factor, Boltzmann distribution, canonical partition function and thermodynamic quantities, energy fluctuations, applications of canonical ensemble. Grand canonical ensemble: Gibbs factor, Gibbs distribution, grand partition function and thermodynamic quantities, particle number fluctuations, applications of grand canonical ensemble. Equipartition theorem: proof of the theorem, applications, specific heat of solids. Maxwell-Boltzmann statistics.

- **Quantum statistics:**

Bosons: occupation number, Bose-Einstein statistics, specific heat of solids (Einstein model and Debye theory), black-body radiation, Bose-Einstein condensation. Fermions: occupation number, Fermi-Dirac statistics, degenerate Fermi gas. Phase equilibria and phase transitions (Qualitative treatment).

Course Outcomes (CO):

At the end of the course a student would be able to

- competently employ a whole host of formalisms of statistical mechanics to a variety of problems in physics, chemistry, biology, computer science, economics and several other disciplines. (CO-1)
- develop the understanding of the fundamental principles and concepts of thermal physics. (CO-2)
- apply quantum statistics to describe the behavior of particles with spins. (CO-3)
- analyze phase equilibria and phase transitions qualitatively, including the interpretation of phase diagrams. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	1	3	3	2	1
CO-2	3	1	3	3	2	1
CO-3	3	1	3	3	2	1
CO-4	3	1	3	3	2	1

Text Books:

- Frederick Reif, Fundamentals of Statistical and Thermal Physics, McGraw-Hill (1965).
- Mehran Kardar, Statistical Physics of Particles, Cambridge University Press (2007).
- Daniel V. Schroeder, An Introduction to Thermal Physics, Addison Wesley Longman (2000).
- R. K. Pathria and Paul D. Beale, Statistical Mechanics, Academic Press (2011).
- L. D. Landau and E. M. Lifshitz, Statistical Physics, Third Edition, Part 1: Volume 5, Pergamon Press (1980).
- Kerson Huang, Statistical Mechanics (Second Edition), Wiley India (2011).
- Harvey Gould and Jan Tobochnik, Statistical and Thermal Physics: With Computer Applications, Princeton University Press (2010).
- James P. Sethna, Statistical Mechanics: Entropy, Order Parameters and Complexity, Oxford University Press (2006).
- S. K. Ma, Statistical Physics, World Scientific Publishing, Singapore, (1985).

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.

PHY422: CONDENSED MATTER PHYSICS

(Credits 4, L-T-P: 3-1-0)

Course description:

Condensed matter physics (CMP) is undoubtedly the most important area of research which often uncover the phenomena that are converted to technology, in particular solid-state device technology used in various fields of sciences. In this course, students will navigate through the behavior of electrons in different materials, explore various types of defects within crystal structures, unravel the mysteries of superconductivity and its applications, and delve into the complexities of magnetism in solids. The students will acquire a profound understanding of the foundational principles and their significance in contemporary technology and scientific advancements.

Prerequisites:

Knowledge of Physics courses upto 5.5 level.

Syllabus:

● Free electron theory:

Free Electron Gas Model and Its Limitations, Electrons Moving in One and Three Dimensional Potential Well, The Density of States, Fermi Energy, Effect of Temperature on Fermi Distribution Function, The Electronic Specific Heat, The Electrical Conductivity of Metals, Relaxation Time and Mean Free Path, The Electrical Resistivity, Bloch Theorem; The Kronig-Penney Model; Symmetry Properties of the Energy Function; Effective Mass of an Electron; The Nearly Free Electron Model and Tight Binding Approximation; Metals; Insulators and Semiconductors.

● Crystal Defects:

Types of defects, Point defects-Vacancies, Interstitials, impurities, electronic, , Line defects- Edge and screw dislocation, Schottky and Frenkel defect Expression for Schottky and Frenkel defects, equilibrium concentration of vacancies, color center, line defect, screw and edge dislocation, Burger's vector and circuit, role of dislocation in plastic deformation and crystal growth, observation of imperfection in the crystals. Frank-Read mechanism. Planar defects, Surface defects- Grain boundaries, Tilt boundaries, Twin boundaries, Effect of Imperfections.

● Superconductivity:

Introduction to Superconductivity, Effect of Magnetic Field, The Meissner Effect, Type I and Type II Superconductors, Entropy, Free Energy, Heat Capacity, Energy gap, Isotope Effect, Thermodynamics of the Superconducting Transition, London Equation and Penetration Depth, Coherence Length, BCS Theory of Superconductivity, Cooper Pair, Flux Quantization, DC and AC Josephson Effects: SQUIDS, High Temperature Superconductivity, Applications of Superconductors.

● Magnetic Properties of Solids:

Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, spin waves and magnons, Curie-Weiss law for susceptibility, ferri and antiferro magnetic order, Domains and Bloch-wall energy.

Course Outcomes (CO):

At the end of this course, the students will be able to

- Gain a comprehensive understanding of the behavior of electrons in solids. (CO-1)
- Identify and analyze various types of crystal defects. (CO-2)
- Explain the phenomenon of superconductivity. (CO-3)
- Understand the magnetic properties of solids. (CO-4)

Mapping of Course Outcomes (COs) with Program Outcomes (POs)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	3	3	2	2
CO-2	3	1	3	3	2	2
CO-3	3	1	3	3	2	2
CO-4	3	2	3	3	2	2

Text Books:

- C. Kittel, Introduction to Solid State Physics, Wiley; Eighth Edition (2012)
- N.W. Ashcroft and N.D. Mermin, Solid State Physics, Brooks/Cole, New Edition (1976)
- J.M. Ziman, Principles of the Theory of Solids, Cambridge University Press; Second Edition (2018)
- A.J. Dekker, Solid State Physics, Laxmi Publications (2008)
- G. Burns, Solid State Physics, Academic Press Inc; Illustrated Edition (1985)
- M. P. Marder, Condensed Matter Physics, Wiley; 2nd Edition (2015)

Assessment Method:

There are two continuous internal assessments (CIAs) and one end semester examination (ESE). Each CIA would be of 20 marks and the ESE would be of 60 marks. The CIA-1 will be in the form of a written examination while the CIA-2 will be in the form of a surprise test, quiz, assignment, or classroom presentation as decided by the course instructor.