Central University of TamilNadu
Thiruvarur.

Syllabus for Integrated M. Sc. (Physics) Program – 2021 - 2023

To be implemented from 2021 Batch onwards

Department of Physics

School of Basic and Applied Physics

Central University of Tamilnadu

Thiruvarur

Central University of Tamil Nadu,
Thiruvarur

Department of Physics
School of Basic and Applied Sciences

Syllabus

Integrated M.Sc Physics (2021-2023)

1.Preamble

The Department of Physics, CUTN was established in the year 2009 with the establishment of the five-year Integrated Masters in Science (Physics) program with a sanctioned strength of 30. There were 17 students in the first batch (2010-2015). A panel of national experts framed the initial structure of the IMSc Program. The aim of the IMSc program was an emphasis on strengthening core-competence in Physics while allowing the students to gain exposure to various other fields from sciences and humanities, thus giving a meaning to the integrated Masters title of the program. A panel of eminent faculty mentored the department until 2012, when the department saw the first set of permanent faculty occupy their positions. With them came the opening of the PhD program in 2013. Right from the inception, to date, invited-faculty, guest-faculty and contractual faculty members have ably supported the department of Physics. Right now the department is having 10 permanent faculty members, who are well trained in National and International Laboratories. They have established a strong research collaboration with the leading Institutions around the world.

The Department of Physics will focus on the following research areas: Computational Condensed Matter Physics, Experimental Condensed Matter Physics, Soft Condensed Matter Physics, Nonlinear dynamics, Statistical Mechanics, Computational Quantum Physics, Simulation of Li-ion battery materials, Modelling of nanophase materials for energy technologies, Design advanced functional materials for solar cell, Semiconductors, Thin films & nanostructures, Experimental High Energy Nuclear and Particle Physics, Atomic, Molecular and Optical Physics (Experimental) and Gravitation & Theoretical Cosmology.. Five-Year Integrated M. Sc. Programme in Physics applies scientific methodologies to understand the most fundamental principles of nature: matter and energy, and how they interact. Energy can take the form of mechanical energy, light energy, electrical energy, radiation energy and sound energy. Physics deals with matter on scales ranging from sub-atomic to stars and even entire galaxies. In this sense, Physics answers questions about universe and the way elements of universe interact to compose natural phenomena.

As well as being concerned with deep fundamental questions, physics forms the basis of most present and future technology like computers, cell phones, lasers and the internet. The Integrated M. Sc. Physics Programme at CUTN aims to train the students in high level theoretical knowledge enabling them to tackle practical complex problems in industrial fields as well as to pursue further academic achievements through research. Since Mathematics, Physics, Chemistry and Life Sciences are fundamental courses in sciences, students will be taught a mix of all these four subjects during the first two years.

The Department of Physics is well-equipped to offer hands-on training in state-of-the-art experiments as par with International standard. After successful completion of fundamental courses, a student will take up core courses in physics. In addition to the core physics subjects, the students can acquire additional expertise in special area of physics in the final year. During this period, all possible opportunities will be created for close interaction with research institutes and industries so as to provide high level training. Thus the main objective of this program is to prepare the younger generation to cope with the emerging scenario in the top level industries, academic and research institutions.

2. Eligibility

A Pass in the Plus two examination or equivalent of any recognized board in India with 60% marks (Physics, Mathematics & Chemistry) for General Category, 55% marks for OBC (Non-creamy layer) and 50% marks for SC/ST/PWD candidates.

3. Vision of the Department

Vision Statement of the Department

The Department of Physics of CUTN envisages itself to be a center of excellence in basic and applied aspects of Physics, both in teaching and research, in next 20 years

4. Mission statements

M1	To establish a world class Department of Physics while being sensitive to the location of the University and the demographics of the student input.
M2	To establish a world class research laboratory with cutting edge technology in multi and trans disciplinary areas of Physics and to train students to develop the high level of global competence in core/ Applied areas of Physics.
M3	To collaborate with Institutes of eminence and Industries for enhanced learning experience through ICT integrated teaching-learning process.

5. Program Outcomes (PO) Integrated Masters Program in Physics

On the successful completion of the program, the student will be able to

PO1	Apply the knowledge gained in fundamental and applied Physics in solving scientific problems at varied complexity, analyze the same to formulate/ develop substantiated solutions.
PO2	Apply the research based knowledge and advanced method to design new experiments, analyze resulting data and interpret the same to provide valid conclusions.
PO3	Gain broad understanding of ethical and professional skill in scientific applicationsin the context of local, global, economic, environmental and societal realities and to develop sustainable practical solution for academic and research problems within professional and ethical boundaries.
PO4	Educate scientifically the new development in Science and Technology and make them critical thinker and innovator.
PO5	Engage in independent and lifelong learning in the broadest context of technological change and pursue his/her carrier either in higher studies or job in various sectors.

6. Specific Outcomes (PSO)

PSO1	Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development.
PSO2	Successfully acquiring jobs after pursuing research in advanced laboratories around the glo0be and build perform as professional teachers in Physics and other science disciplines.
PSO3	Provide the professional services to industry, research organisation and institutes in India and overseas.
PSO4	Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations.
PSO5	Provide value based and ethical leadership in the professional and social life.

7. Graduate Attributes

1. Disciplinary/ interdisciplinary knowledge;
2. Computational and ICT skills/ digital literacy.
3. Communication skills.
4. Ethics/ moral awareness.
5. Problems solving/ Analytical/ reflective thinking.
6. Critical thinking
7. Cooperation/ team work.
8. Self-directed learning.
9. Research related skills.

8. PSO to Mission Statement Mapping

	PEO1	PEO2	PEO3	PEO4	PEO5
M1	x	x	x	x	x
M2	x	x	x	x	x
M3	x	x	x	x	x

9. PO to PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6
PSO1	x	X	x	x	x	x
PSO2	x	X	x	x	x	x
PSO3	x	X	x	x	x	x
PSO4	x	X	x	x	x	x
PSO5	x	X	x	x	x	x

10. Programme structure

Course Code	Course Title	Type (Core / DSE/SEC/ AECC/AU	Theory /Practical/Lab	L:T:P	Total Credits
SEMESTER - I					
PHY111	Mechanics	Core	Theory		3
PHY112	Physics Laboratory- I	Core	Practical		2
SEMESTER - II					
PHY121	Waves, Oscillations, Sound and Optics	Core	Theory		3
PHY122	Physics Laboratory –II Wave,Oscillations, Sound, and Optics	Core	Practical		2
SEMESTER - III					
PHY211	Heat and Thermodynamics	Core	Theory		3
PHY212	Physics Laboratory- III	Core	Practical		2
SEMESTER - IV					
PHY221	Electricity and Magnetism	Core	Theory		3
PHY222	Physics Laboratory - IV Electricity and Magnetism	Core	Practical		2
SEMESTER - V					
PHY311	Mathematical Physics I	Core	Theory		4
PHY312	Classical Mechanics	Core	Theory		4
PHY313	Morden Physics & Relativity	Core	Theory		4
PHY314	Physics Laboratory-V Morden Physicss	Core	Practical		2
PHY351	Numerical Methods and Computer programming	DSE	Theory		4

PHY352	Computational Laboratory- I	DSE	Practical		2
PHY371	Machine shop	SEC	Theory		
SEMESTER - VI					
PHY321	Mathematical Physics II	Core	Theory		4
PHY322	Quantum Mechanics I	Core	Theory		4
PHY323	Electro Magnetic Theory	Core	Theory		4
PHY324	Condensed Matter Physics - I	Core	Theory		4
PHY325	Condensed Matter Physics - Lab	Core	Practical		2
PHY326	Minor Project	Core	Project		6
PHY0E15	Introduction to Nonlinear Dynamics	Elective	Theory		4
PHY0E32	Astrophysics	Elective	Theory		4
PHY0E02	Semiconductor Physics	Elective	Theory		4
SEMESTER - VII					
PHY411	Quantum Mechanics II	Core	Theory		4
PHY412	Atomic and Molecular Physics	Core	Theory		4
PHY413	Statistical Mechanics	Core	Theory		4
PHY414	Atomic physics and optics lab	Core	Practical		2
PHY451	Electronics	DSE	Theory		4
PHY452	Electronics Lab	DSE	Practical		2
SEMESTER - VIII					
PHY421	Modern Optics	Core	Theory		4
PHY422	Nuclear and Particle Physics	Core	Theory		4
PHY461	Laser Physics	DSE	Theory		4
PHY462	Laser Physics Laboratory	DSE	Practical		2
PHY463	Experimental Methods and Design	DSE	Theory		4
PHY464	Experimental Techniques Lab	DSE	Practical		2
SEMESTER - IX					
PHY511	Condensed Matter Physics-II	Core	Theory		4
PHY551	Computational Physics	DSE	Theory		4
PHY552	Computational Laboratory- II	DSE	Practical		2
PHY571	Advanced Physics Laboratory	SEC	Practical		2
PHYS01	Physics of art	General Elective	Theory		2

Elective

PHY0E01	Solar Energy and its application	Elective	Theory		4
PHY0E02	Semiconductor Physics	Elective	Theory		4
PHY0E03	Properties of Material	Elective	Theory		4
PHY0E04	Physics of material and synthesis	Elective	Theory		4
PHY0E15	Introduction of Nonlinear	Elective	Theory		4
PHY0E23	Advanced Electro magnetic theory	Elective	Theory		4
PHY0E29	Nano material and Nano technology	Elective	Theory		4
PHY0E30	Physics of magnetism and spintronics	Elective	Theory		4
PHY0E32	Astrophysics	Elective	Theory		4
PHY0E33	Plasma Physics	Elective	Theory		4
PHY0E34	Classical Field theory	Elective	Theory		4

11. Evaluation Scheme

Components	**Weightage (%)**
(Internals I & II	40
End Semester Exams	60

12. Syllabus

12.1 Course Content

Semester - I

Course Code:PHY111 **Course Title: MECHANICS PHY111**		**Theory**	**Credits 3**
Unit -1	Fundamentals of Dynamics: Reference frames, Inertial frames, Galilean transformations, Galilean invariance, Review of Newton's Laws of Motion. Momentum of variable mass system: motion of rocket. Dynamics of a system of particles. Principle of conservation of momentum, energy. Impulse. Determination of Centre of Mass of discrete and continuous objects having cylindrical and spherical symmetry (1-D, 2-D & 3-D). Conservative and non- conservative forces. Phase space diagram for one dimensional systems, Stable, unstable and neutral equilibrium. Force as gradient of potential energy. Work energy theorem, Work done by non-conservative forces. Collisions: Elastic (1-D and 2-D) and inelastic collisions. Centre of Mass and Laboratory frames.		Hours* 9
Unit -2	Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of inertia, theorem of parallel and perpendicular axes. Determination of moment of inertia of		**9**

	discrete and continuous objects [1-D, 2-D & 3-D (rectangular, cylindrical and spherical)]. Kinetic energy of rotation. Motion involving both translation and rotation. Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame.Centrifugal force. Coriolis force and its applications.	
Unit -3	Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field: Two-body problem, its reduction to one- body problem and its solution. Reduction of angular momentum, kinetic energy and total energy. The energy equation and energy diagram. Derivation of Kepler's Laws and elliptical orbits. Satellite in circular orbit, Geosynchronous orbits.	**9**
Unit -4	Oscillations: Idea of SHM. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Compound pendulum. Damped oscillation. Forced oscillations: Transient and steady states, sharpness of resonance and Quality Factor.	**9**
Unit -5	Fluid statics, Pressure and density, Buoyancy, Archimede's principle, Introduction to surface tension, Derivation and applications of Hydrostatic equation Free surface energy, excess pressure – application to spherical, cylindrical drops and bubbles, variation of surface tension with temperature – Jaegar's method, Fluid flow, stream lines and tubes of flow, Equation of continuity; Euler's equation and Navier strokes equation for fluid flow, Bernoulli s theorem -applications, Fluid friction and coefficient of viscosity. Poiseuilles equation for incompressible fluids; Stokes law; terminal velocity,effect of temperature on viscosity; Reynolds number	**9**
	Tasks and Assignments: **References:** 1. An Introduction to Mechanics (2/e), Daniel Kleppner & Robert Kolenkow. 2. Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., (McGraw Hill).	

Course Outcomes

	Course Outcome	**Level**
CO 1	Define terms in Mechanics such as force, potential energy, work done and write the Newton laws of motion for various forces.	Remember
CO 2	The concept of elastic & inelastic collisions, motion under a central force, idea of simple harmonic motions, and relativistic mechanics.	Understand
CO 3	Apply the Kepler's laws to planetary motions and ideas of Coriolis force and solve problems related to it.	Apply
CO4	Analyze the motion of particles under various types of forces and the simple harmonic motion including damping and forced oscillations	Analyze
CO5	Solve problems related to Newton's equations of motion, central forces, and Special theory of relativity.	Skill

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓			✓	✓
CO2	✓	✓		✓	✓
CO3	✓			✓	✓
CO4	✓	✓		✓	✓
CO5	✓			✓	✓

Course Code: PHY112 **Course Title: Physics Laboratory-I (Mechanics)**	**Practical**	**Credits: 2**

	List of Experiments Preliminary experiments (a) Vernier calipers (b) Screw gauge (c) Physical Balance. (d) Travelling Microscope Core experiments 1. Young’s modulus – cantilever bending 2. Young’s modulus –Koenig’s Method 3. Torsional Pendulum 4. Verification of Hooke’s law 5. Projectile motion 6. Conservation of momentum 7. Conservation of energy 8. Archimedes principle 9. Centripetal force 10. Measurement of surface tension using capillary rise method.	
	Tasks and Assignments: 1. Virtually executing the experiments 2. Observation submission 3. Viva-Voce 4. Practical Examination	

	References: 1. Virtual labs, https://www.vlab.co.in/ 2. An Introduction to Mechanics – D. Kleppner and R.J. Kolenkow (Tata McGraw-Hill) 3. Mechanics - K. R. Symon (Addison-Wesley). 4. Mechanics and General Properties of Matter – D. P. Roychaudhuri and S. N. Maiti(Book Syndicate).

Course Outcomes

	Course Outcome	Level
CO 1	Students can understand the basics of mechanics and its working principles	Understand
CO 2	Students can execute those experiments virtually	Virtual
CO 3	Students can utilize the technology to do the experiments	utilizing
CO4	Students can do this practical experiments with various options which is not available do physically	experimental
CO5	Students can develop their self-knowledge to think for the innovative ideas for the virtual experiments	Research

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1					
CO2					
CO3	**x**		**x**	**x**	
CO4		**x**			
CO5					**x**

Semester –II

Course code:PHY121 **Course Title: Waves, Oscillations, Sound and Optics**	**Theory**	**Credits 3**
Unit -1	Simple harmonic motion; damped and forced vibrations: amplitude and velocity resonance. Linearity and Superposition Principle. Superposition of two collinear oscillations having equal frequencies and different frequencies (Beats). Superposition of two perpendicular Harmonic oscillations, Superposition of N collinear Harmonic Oscillations, coupled harmonic oscillators.	Hours **10**
Unit -2	Transverse vibrations in stretched strings, Wave equation in the linear approximation - Speed, Energy of transverse vibrations, Linear equation of plane progressive wave motion in one dimension; wave propagation - group velocity and phase velocity;Traveling waves, Wave speed, Power and intensity in wave motion, Interference of sound waves, Stationary waves.	**10**
Unit -3	Sound waves as pressure fluctuations, speed of sound waves in liquids, solids and gases, Sound intensity, decibel scale; musical sound and noise, characteristics of musical sound: Loudness, noise, quality and intensity; standing sound waves and normal modes, interference and beats, The Doppler effect; shock waves; velocity of sound and its measurement, factors affecting the speed of sound; ultrasonic and infrasonic waves.	**10**

Unit -4	Nature and propagation of light, Reflection, Refraction, Fermat's principle, Images, Plane mirrors, Spherical mirrors, Spherical refracting surfaces, Lenses, Defects of images, Spherical and Chromatic aberrations;Achromatism of two thin lenses separated by a distance; Stops, Prisms: dispersion, minimum deviation.	**11**
Unit -5	Electromagnetic nature of light; definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. Introduction to Interference and Diffraction.	**4**
	References: 1. *The Physics of Vibrations and Waves,* H. J. Pain (John Wiley & Sons Ltd.) 2. *Waves: Berkeley Physics Course Vol. 3,* F. S. Crawford (McGraw Hill Education) 3. *University Physics with Modern Physics*, Sears & Zemansky's (Addison-Wesley-Pearson) 4. Optics, Ajoy Ghatak (McGraw Hil) 5. *Fundamentals of Physics*, Halliday & Resnick (Wiley)	

12.2 Course Outcomes

	Course Outcome	**Level**
CO 1	Understanding essential concepts of oscillations which would serve as a foundation to solve many difficult problems in other areas of Physics.	Understand Skill
CO 2	Learning basic concepts of various waves.	Understand
CO 3	Understanding the origin, properties and application of sound waves.	Understand Apply
CO4	Enabling to understand the principle to build optical instruments.	Apply Skill
CO5	Introduction to the wave nature of light.	Understand

12.3 Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1			✓	✓	✓
CO2				✓	✓
CO3	✓			✓	✓
CO4	✓	✓		✓	✓
CO5				✓	✓

Course Code: PHY122, **Course Title: Physics Laboratory-II (Waves, Oscillations, Sound, and Optics)**	**Practical**	**Credits: 2**
	List of Experiment 1. Simple pendulum and Compound pendulum 2. Resonance air column and water column 3. Newton's rings 4. Sonometer 5. Focal length 'f' of lenses 6. Angle of prism and minimum deviation of solid prism 7. Diffraction using grating. 8. Air wedge. 9. Angle of prism and minimum deviation of liquid prism	
	Tasks and Assignments: 1. Virtually executing the experiments	

	2. Observation submission 3. Viva-Voce 4. Practical Examination **References:** 1. Virtual labs, https://www.vlab.co.in/ 2. David Halliday, Robert Resnick and Jearl Walker (2004) Fundamentals of Physics. 7th edition. John Wiley & Sons. 8th Ed. (2008). 3. F. W. Sears, M. W. Zemansky, and H D Young, University Physics, Addison Wesley (1976). **4.** Optics, Ajoy Ghatak, Fourth Edition (2009), Tata McGraw Hill.

Course Outcomes

	Course Outcome	Level
CO 1	Students can understand the basics of Wave, Oscillations, Sound, and Optics and its working principles	Understand
CO 2	Students can execute those experiments virtually	Virtual
CO 3	Students can utilize the technology to do the experiments	Utilizing
CO4	Students can do this practical experiments with various options which is not available do physically	Experimental
CO5	Students can develop their self-knowledge to think for the innovative ideas for the virtual experiments	Research

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1					
CO2					
CO3	x		x	x	
CO4		x			
CO5					x

Semester -III

Course code:PHY211 Course Title: Heat and Thermodynamics		Theory	Credits 3
Unit -1	Thermal equilibrium and notion of temperature; Zeroth law of thermodynamics; Thermometers and temperature scales: Celsius and Fahrenheit scales; Heat conduction, thermal conductivity, Derivation of Maxwell's law of distribution of velocities for ideal gases, Mean, RMS and Most Probable Speeds. Collisions and mean free path, Law of equipartition of energy and its applications to specific heat of gases.		Hours **9**
Unit -2	Transport Phenomena: Viscosity, Conduction and Diffusion; Behavior of Real Gases: deviations from the Ideal Gas Equation. Andrew‟s Experiments on CO2 Gas, Continuity of Liquid and Gaseous State; van der Waal's Equation of State for Real Gases. critical temperature, critical pressure and critical volume; The Virial Expansion, discussion about various equations of state.		**9**

Unit -3	Extensive and intensive thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics and Concept of Temperature, Concept of Work and Heat, State Functions, Internal Energy, First Law of Thermodynamics, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P and C_V, work done in isothermal and adiabatic Processes, Compressibility and Expansion Co-efficient.	**9**
Unit -4	Reversible and Irreversible processes, Heat Engines, Refrigerators, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot"s Theorem. Entropy, Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes. Temperature–Entropy diagrams for Carnot's Cycle. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. Third Law of Thermodynamics, Unattainability of Absolute Zero.	**10**
Unit -5	Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications: Joule-Thompson Effect, Clausius- Clapeyron Equation, Ehrenfest equations. T-dS equations. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions. Introduction to Statistics of particles: Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac Statistics (qualitative).	**8**
	References: 1. *Heat and thermodynamics*, Zemansky and Ditman (Mc Graw Hill) 2. *Thermal Physics*, S. C. Garg, R. M. Bansal and C. K. Ghosh (Tata McGraw Hill Education Private Ltd.) 3. *A Treatise on Heat*, Saha and Sribastava (The Indian Press Ltd.) 4. *Fundamentals of Statistical and Thermal Physics*, F. Reif (McGraw Hill Book Company) 5. Heat and Thermodynamics – H. P. Roy and A. B. Gupta (Books & Allied Ltd.)	

12.2 Course Outcomes

	Course Outcome	Level
CO 1	Understanding thermal equilibrium, concept about heat and temperature. Learning heat transfer mechanisms. Learning how to relate quantitatively heat transfer into work done using the first law of thermodynamics	Understand Apply
CO 2	Understanding the second and the third law of thermodynamics as well as their applications.	Understand Apply
CO 3	Learning about thermodynamic potentials and their application in various processes including phase transitions.	Understand Apply
CO4	Learning how to relate the macroscopic properties of a system to its microscopic properties using kinetic theory.	Understand Apply Skill
CO5	Understanding how the interactions at the molecular level determine the thermal properties of the substance.	Understand Apply

12.3 Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓		✓

CO3	✓	✓			
CO4	✓	✓	✓		✓
CO5	✓	✓		✓	

Course Code: PHY212 **Course Title: Physics Laboratory- III (Heat and Thermodynamics lab**	**Practical**		**Credits 2**
	Preliminary experiments: An introduction to the subject Temperature of mixing - mix hot and cold water - note their initial and final temperature - try and predict the final temperature 1. Galton's board 2. Thermometry - Measuring temperature using different thermometers such as (a) alcohol (b) mercury (c) IR (contact less) (d) digital (e) min-max (f) dry-wet (for humidity) 3. Place a cube of ice on three different black colored boards - one made of metal, one of wood and one of plastic - qualitative concepts of specific heats and thermal conductivity	Hours* **6**	
	Core Experiments 1. Newton's law of cooling 2. Pressure coefficient of air - Joly's bulb 3. Thermal conductivity of a good conductor - Searle's method 4. Thermal conductivity of a bad conductor - Lee's method 5. Specific heat by method of mixtures 6. Verification of Stefan-Boltzmann law 7. Latent heat of steam/ice 8. Verification of Boyle's law 9. Seeback effect and thermocouple 10. Mechanical equivalent of heat	**30**	

Course Outcomes

	Course Outcome	Level
CO 1	Understand notion of heat, randomness and temperature using different systems	Understand
CO 2	Illustrate different thermodynamics concepts by employing various experiments.	Apply
CO 3	Compare and examine the experimental result with theoretical predictions.	Analyze
CO4	Arrange for the experiment, Demonstrate and Verify the Hypothesis.	Skill

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish

Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓			✓	✓
CO2	✓	✓		✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓

Semester- IV

Course Code: PHY221 **Course Title: Electricity and Magnetism**	**Theory**	**Credits** **3**
Unit -1	Electrostatics: Brief recap of vector analysis, Coulomb’s law, Electric field, Divergence and curl of electric field, electrostatic potential, dipole,; principle of superposition, relation between electric field and potential; Electric field and potential of different charge configurations such as, rings, discs, planes , spheres, Earnshaw’s theorem, equipotential surfaces	9 Hours
Unit -2	Electrostatic energy, Basic concept of conductor and induced charge, Conductors in an electrostatic field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel plate capacitor, capacitance of an isolated conductor. Dielectrics, Polarisation, Displacement vector. Gauss's theorem, electrical susceptibility, permittivity and dielectric constant, energy in dielectric system. Method of Images and its application to plane infinite sheet of charge and charged sphere.	9 Hours
Unit -3	Magnetostatics: Biot-Savarts law, magnetic field due to a straight, circular conductor and solenoid, force between parallel conductors, Amper’s law, Lorentz force, Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance. Energy stored in magnetic field, measurement of magnetic permeability and susceptibility, basic ideas of para, ferro – and diamagnetism, cycle of magnetization, hysteresis, energy loss due to hysteresis.	9 Hours
Unit -4	Ampere’s theorem and of its applications; Resistors and Ohm’s law, Kirchoff’ laws, conservation theorems and their applications; Norton and Thevenin theorem, maximum power transfer theorem, Wheatstone bridge, moving coil galvanometers, ballistic galvanometer, Ammeters and Voltmeter.	9 Hours
Unit -5	Alternating currents: A.C. Resonance circuits – RC, LC and RLC circuits. Phasor representation and Q factor. Impedance of series and parallel resonant circuits. Introduction to Maxwells’s equations in vacuum	9 Hours
	Tasks and Assignments: **References:** 1) Introduction to Electrodynamics, D J Griffiths. 2) Brijlal and Subramaniam, “Electricity and Magnetism”,	

	3) Electronic principles, A. Malivino D. Bates 4) Electricity and Magnetism, Satya Prakash

Course Outcomes

	Course Outcome	Level
CO 1	Coulomb's law, Gauss law, Stoke's theorem, Earnshaw's theorem, Ampere's law, , Faraday's law, Lentz's law, Lorentz' law, Biot-Savart Law, Ohm's law, Kirchoff's law, Norton and Thevenin theorem	Remember
CO 2	Vector analysis, electric field and potential, magnetic field and potential, dielectric medium, capacitance, magnetism, self and mutual inductance, circuit analysis, alternating current circuits, Maxwell's equation.	Understand
CO 3	To find out the electric field and potential for different charge configurations, method image to find electric field and potentials, Use Biot-Savart Law to find magnetic field for different configurations of current carrying conductor, solving different circuit problems using circuit theorem, solving series and parallel a.c circuit having resistance, inductance and conductance.	Apply
CO4	Applying vector analysis to solve problems of electricity and magnetism, using different laws and theorems of electrostatisc and magnetostatics to solve electricity and magnetism problems, to use this to basic knowledge for studying Electrodynamics.	Skill

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

Course Code: PHY222, Course Title: Physics Laboratory- IV (Electricity and Magnetism)	**Practical**	**Credits: 2**
	Preliminary experiments: 1. Mapping of electrical field lines for different charges and charge configurations. 2. Mapping of magnetic field lines using a bar magnet and compass/iron filings 3. Lenz's Law – take two identical copper pipes – drop a steel ball and a magnet – magnet will take much longer to fall 4. Shielding of Magnetic fields by different materials using a rare earth magnet and gauss meter **Core experiments:** 1.. Verification of Kirchoff's laws 2. Resonance in LCR Circuits and Transient response of resonant circuit 3. Conversion of Voltmeter to Ammeter. And ammeter to Voltmeter 4. Hysteresis curve 5. Measurement of Average Resistance of a Wire by Carey-Foster Method and hence to determine the Value of Unknown Resistance 6. Charging and Discharging a Capacitor	

	7. Determination of the Moment of a Bar Magnet and the Horizontal Component of Earth's Magnetic Field by Magnetometers 8. Comparison of EMF of cells using by potentiometer. . Determination earth magnetic field using by tangent galvanometer and determination of reduction factor of given tangentgalvanometer. 10. Kelvin double bridge 11. Verification of Network Theorems (Thevenin, nortans and super position theorem) 12. construction of passive filters (low pass, Band pass)	
	Tasks and Assignments: 1. Virtually executing the experiments 2. Observation submission 3. Viva-Voce 4. Practical Examination **References:** 1. Virtual labs, https://www.vlab.co.in/ 2. Brijlal and Subramaniam, "Electricity and Magnetism", Ratan Prahasan Mardis Educational and University Publishers, Delhi, 1990 3. Jacob Millman and Christos C Halkias, "Electronic Devices and Circuits", Tata McGraw Hill Edition, 1991.	

Course Outcomes

	Course Outcome	Level
CO 1	Students can understand the fundamentals of electricity and magnetism	Fundamental
CO 2	Students can execute those experiments virtually	Virtual
CO 3	Students can utilize the technology to do the experiments	Utilizing
CO4	Students can do this practical experiments with various options which is not available do physically	Experimental
CO5	Students can develop their self-knowledge to think for the innovative ideas for the virtual experiments	Higher study

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	**x**				
CO2					
CO3			**x**	**x**	
CO4		**x**			
CO5					**x**

Semester – V

Course Code: PHY 311 **Course Title: MATHEMATICAL PHYSICS - I**	**Theory**	**Credits 4**
Unit -1	Functions of real variables, features of a function, sketching functions - powers of *x*, family of ovals and spirals, interpreting graph of functions using the concepts of calculus. Functions represented by integrals - error function, complementary error function, Fresnel integral, Gamma function, Gaussian integral in 1, 2 and 3 dimensions, step function θ , Dirac delta function - Defining relation, sequences of function tending to δ-function, relation between θ and δ function, properties of Dirac delta function,derivative of δ	Hours 10

	function.	
Unit -2	Ordinary and partial Differential Equations: Linear ordinary differentialequations – Elementary methods – Linear second order differential equations withvariable coefficients – Frobenius method wronskian physical example. Method of forming partialdifferential equations – Solution by direct integration – Method of separation of variables – Partial differential equations in physics problems – Wave equation – Equation ofvibrating string –One dimensional heat flow – Two dimensional heat flow – Laplaceequation.	14
Unit -3	Linear Vector Spaces and its dual, Linear Dependence and Independence ofvectors, Basis and Dimensions, Infinite dimensional vector space- Hilbert space, subspace, Rank and Nullity of a Matrix, Examples from Real Function Space and Polynomial Space, Orthogonal Vectors, Orthogonal Basis, Gram- Schmidt process of generating an Orthonormal Basis, Change of basis. Linear Transformations. Representation of Linear Transformations by Matrices. Hermitian and Skew- Hermitian Matrices. Orthogonal and Unitary Matrices. Similar Matrices. Inner Product. Properties of Eigen- values and Eigen Vectors of Orthogonal, Hermitian and Unitary Matrices. Exponential of a Matrix.	16
Unit -4	Cartesian Tensor: Transformation of co-ordinates, Einstein's summation convention, Tensors, Algebra of Tensors: Sum, Difference and Product of Two Tensors. Contraction, Quotient Law of Tensors, Symmetric and Anti-symmetric Tensors, Kronecker and Alternating Tensors. Application of cartesian tensor: Vector Algebra and calculus using Cartesian Tensors: Scalar and Vector Products, Gradient, Divergence and Curl of Tensor Fields. Vector Identities.	12
Unit -5	Group Theory: Definition of group symmetry elements homomorphisms; isomorphism; Subgroups and cyclic groups; Cosets; Abelian groups, Reducible and irreducible representation – Character table;	8
	Tasks and Assignments: **References:** 1. Mathematical methods for physicists: G.B.Arfken, Hans Webber 2. . Mathematical methods for physics and engineering: K.F.Riley, M.P.Hobson et. al.	

12.2 Course Outcomes

	Course Outcome	Level
CO 1	To get an idea of functions used in most of the physical systems, their basic properties and behaviour. Acquire the skill to get qualitative features of functions which can be used while analysing solutions of a physical problem.	Remember, Understand,Skill

CO 2	Learn to translate physical situation into mathematical equations, find out solutions of the mathematical equations, analyze and interpret the solutions	Apply, Evaluate, Analyse, Skill
CO 3	To learn the abstract way of defining quantities like space, dimensionality of spaces etc which can be applied in various branches of physics.	Understand, Apply
CO4	Learn the technique of tensor notation	Skill
CO5	Application of tensor notation in analysing various physical systems.	Apply, Analyse

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration ofcomprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a newcontext	Employ, Illustrate, Use, Solve
Analyze – supporting assertions throughthe use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on thevalue of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come tonew conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

12.3 Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓		
CO2	✓	✓	✓		
CO3	✓	✓	✓	✓	
CO4	✓	✓			
CO5	✓	✓			

Course Code: PHY 312 **Course Title: CLASSICAL MECHANICS**	**Theory**	**Credits 4**
Unit -1	**Langrangian Formulation** System of particles, Newtonian mechanics, classification of constraints - degrees of freedom – generalized coordinates- conservation of linear and angular momenta- D'Alemberts principle	Hours 12

	of virtual work- Lagrange's equation of motion – applications of Lagrange's equation of motion –applications of Lagrange equations of motion; single particle in space-Atwood's machine-bead sliding in rotating wire - Kepler's problem- Spherical Pendulum, generalized momenta, Routh's procedure, symmetry properties and conservations theorems, one and higher dimensional harmonic oscillator.	
Unit -2	**Hamilton Principle** Calculus of variation – Liouville theorem-Hamilton's principle – derivation of Lagrange's equation from Hamilton's principle – Hamilton's principle for nonholonomic system-variational principle – Legendre transformation and Hamilton's equations of motion – cyclic coordinates and conservation theorem – Hamilton's equations from variational principle –principle of least action– Solving the Harmonic Oscillator problem using canonical transforms- Application of Hamiltonian Equation of motion: (i) simple pendulum, (ii) Compound pendulum (iii) Two dimensional Isotropic Harmonic oscillator, (iv) Linear Harmonic oscillator, (v) Particle in central field of force-Canonical transformations- angular momentum using Poisson brackets- Jacobian Identity - Generating functions –Examples – Poisson brackets and its properties	**12**
Unit -3	**Small Oscillations** Small oscillations of dynamical systems, equilibria and derivations, frequencies of free vibrations and normal coordinates and normal modes; motion of masses connected by springs –vibrations oflinear triatomic molecule.	**12**
Unit -4	**Kinematics of Rigid Body** Independent coordinates of rigid body – orthogonal transformation – properties of transformation matrix – Euler angles and Euler's theorem – infinitesimal rotation –rate of change of vector – Coriolis force – angular momentum and kinetic energy of motion about a point – moment of inertia tensor – Euler's equations of motion – torque free motion of a rigid body –heavy symmetrical top.	**12**
Unit -5	**Hamilton –Jacobi Theory** Hamilton–Jacobi equation for Hamilton's Principle function-Example; Harmonic oscillator problem- Hamilton's characteristic function – Action – angle variable in systems of degree of freedom-application of angle of action to Kepler problem and simple harmonic oscillator.	**12**

Course Outcomes

	Course Outcome	**Level**
CO 1	To gain deeper understanding of the classical mechanics principles such as constraints, generalised coordinates, D'Alemberts principle, Lagrangian and Hamiltonian formulations and also describing the basics of one and higher dimensional harmonic oscillators.	
CO 2	To be able to formulate and solve the problems on canonical transformations, Poisson brackets, Jacobi identity and Harmonic oscillators.	

CO 3	To understand and apply problems based on Theory of small oscillations, normal modes and frequencies.	
CO4	To understand the motion of rigid body and other advanced mathematics in the solution of the problems of mechanical systems. Describe and understand the motion of the forces in non-inertial systems.	
CO5	To solve Hamilton Jacobi equation and action angle variables in systems of degree of freedom and its application to Kepler problem and harmonic oscillator.	

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓		✓
CO2		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓		✓	✓	
CO5	✓	✓	✓	✓	✓

Course Code- PHY 313 **Course Title: Modern Physics and Relativity**	**Theory**	**Credits 4**
Unit -1	Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson- Germer experiment. Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra, Stern- Gerlach experiment and spin.	Hours 12
Unit -2	Wave-particle duality, Heisenberg uncertainty principle, Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude.	12
Unit -3	Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension. One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization, Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier.	12
Unit -4	Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.	8
Unit -5	Special Theory of Relativity: Outcomes of Michelson-Morley Experiment. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity, Length contraction, Time dilation. Relativistic transformation of velocity, acceleration, frequency and wave number. Mass of relativistic particle. Mass-less Particles. Mass-energy Equivalence. Relativistic Doppler effect (transverse and longitudinal). Relativistic Kinematics (decay problems, inelastic	16

	collisions and Compton effect). Transformation of Energy and Momentum.	

12.2 Course Outcomes

	Course Outcome	Level
CO 1	To emphasise the important of various experiments that lead to the development of quantum mechanics	Remember, Understand
CO 2	Concept of wave-particle duality, the uncertainty principle and its application, importance of superposition principle	Remember, Understand
CO 3	Plausibility arguments leading to Schrodinger equation (SE), wave functions and probabilistic interpretation, Conditions for a valid wave function, concepts stationary states. Solve SE for some simple systems.	Understand, Apply
CO4	Give the idea of atomic scale, application of uncertainty principle, idea of radioactivity and various decay process	Remember, Understand, Apply
CO5	Idea of molecular scale and give the glimpse of solid state physics	Remember, Understand

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

12.3 Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	

CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	

Course Code-:PHY314 **Course Title: Physics Laboratory –V (Modern Physics)**		**Practical**	**Credits 2**
1	Millikan's Oil Drop Method		Hours 3
2	Rydberg Constant		**3**
3	Balmer –Emission Spectra		**3**
4	Frank –Hertz Experiment		**3**
5	Zeeman Effect		**3**
6	e/m by Thomson method		**3**
7	Electron Spin Resonance		**3**
8	Compton Effect		**3**
9	Black body radiation		**3**
10	Photoelectric effect		**3**

Course Outcomes

	Course Outcome	**Level**
CO 1	Study the properties of electrons, photons, and electron-photon interactions	Remember
CO2	Experimental basis of the Quantum Theory of Matter	Understand
CO3	Verification of properties of electrons like charge, e/m ratio, existence of spin	Apply
CO4	Distinguish between theoretical predications & experiment measurements	Analyse
CO5	Hands-on experience with experiments in modern physics and collection of data	Apply

General Objectives	**Specific Objectives**
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓		
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	

Course Code: PHY351 **Course Title: Numerical Methods and Computer programming**	**Theory**	**Credits** **4**

Unit -1	Different number system-decimal, binary, octal, hexadecimal, Number representation in computer, Approximations and round off errors: Significant digits, true/absolute and truncation errors, Taylor Series – Taylor polynomial error formula. Determination of roots of polynomials and transcendental equations: Bisection methods, Newton•-Raphson method, Secant method and Bairstow's method. Solutions of linear simultaneous linear algebraic equations by Gauss Elimination and Gauss•-Seidel iteration methods.	Hours 12
Unit -2	Backward, Forward and Central difference relations and their uses in Numerical differentiation and integration, Application of difference relations in the solution of partial differential equations. Numerical solution of ordinary differential equations by Euler, Modified Euler, Runge•Kutta and Predictor•Corrector method.	12
Unit -3	Numerical integration: midpoint rule, trapezeoidal method, Simpson's method, Newton•Cotes method, Gaussian rules. Linear interpolation: Vandermonde polynomial method (Direct method), Newton polynomial and Lagrange method. Least squares approximation, Curve fitting:• fitting data to a straight line, fitting data to linear combinations of functions, Goodness of a fitting: Chi-square test.	12
Unit -4	UNIX commands, editors (e.g. vi, gedit), Arithmetic expressions, Concepts of variables, expressions and statements, program statements and function calls from the library (printf for example) data types • int, char, float etc. expressions, arithmetic operations, relational and logic operations. Assignment statements, extension of assignment to the operations. Statements, conditional execution using if, else. Optionally switch and break statements may be mentioned.	12
Unit -5	Branching of a program – branch, loop, conditional loops. Concepts of loops, example of loops in C using for, while and do-•while, continue. One dimensional arrays and examples of iterative programs using arrays, 2•d arrays. Use in matrix computations. Concept of Sub• programming, functions. Example of functions. Argument passing mainly for the simple variables. Pointers, relationship between arrays and pointers. Argument passing using pointers. Array of pointers, Passing arrays as arguments. GNU-plotting for data visualisation.	12

Course Outcomes

	Course Outcome	Level
CO 1	Number system, Unix commands, program syntax and numerical techniques.	Remember
CO 2	Taylor series expansion, Root finding methods, numerical methods to solve linear and differential equation, curve fitting and plotting	Understand
CO 3	The theoretical procedure of various root finding methods and finding solutions for linear differential equations in computer programs and solve numerical problems. GNU plot for data visualization.	Apply
CO4	Skill to solve numerical problems using computer programs and use of different programming techniques for efficient programs.	Skill

Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

Course Code: PHY352 **Course Title: Physics Laboratory VI (Computational Physics- I)**	**Practical**	**Credits** **2**
1.	**(Any language: C/C++/Python)** Environment walkthrough (Editor, Unix commands), primitive types, assignment, arithmetic expressions, simple I/O.	
2.	Find values of: (i) sin x, (ii) cos x, (iii) exp(x) considering their series expansion	
3.	Add, multiply and find inverse of a given (3x3) matrix	
4.	Find the roots of a given quadratic equation by using any one: Bisection methods, Newton-Raphson method, Secant method and Bairstow's method	
5.	Solve the given three simultaneous equations by elimination method.	
6.	Solve first order, homogeneous, linear differential equation	
7.	Solve numerical integration problem by (any two methods): trapezoidal method, Simpson’s method, Gaussian rules.	
8.	Design of Class in C++ (optional), GNU Plotting: plot standard and user defined functions. Fit a straight line or a parabolic curve to a given set a data	

Course Outcomes

	Course Outcome	Level
CO 1	Unix commands, program syntax	Remember
CO 2	Passing of arguments, arithmetic operations, use of inbuilt and user-defined functions, program control	Understand
CO 3	To solve numerical problems using function methods, array, pointer and plotting	Apply
CO4	Skill to solve numerical problems using computer programs and use of different programming techniques for efficient programs.	Skill

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

Course Code: PHY371 **Course Title: Machine shop**		**Practical**	**Credits: 2**
Part A:	1. Lines and Lettering 2. Scales and paper sizes 3. Title blocks 4. Basic instruments used a) T-square b) Set-square c) Parallel rules d) Drafting Machine 5. Axonometric projections a) Dimetric projection b) Isometric projection 6. Orthographic projection a) First angle projection b) Third angle projection 7. Introduction to CAD		
Part B:	1. Introduction to machine tools 2. Safety aspects in machine shop 3. Milling 4. Turning 5. Shaping 6. Filing 7. Keyway/slot/groove making 8. Surface/slot milling		

References:

1. R.K. Dhawan, “A text book of Engineering Drawing”, S. Chand Publishers, Delhi,2010.
2.G.S. Phull and H.S.Sandhu, “Engineering Graphics”, Wiley Publications, 2014.
3. K.Venugopal and V.Prabhu Raja, “Engineering Graphics”, New Age International Private Limited, 2008.
4. P.J.Shah, A Text Book of Engineering Graphics, S.Chand & Company Ltd.

Course Outcomes

	Course Outcome	Level
CO 1	Technical understanding and broaden perspective of the engineering drawing and manufacturing/ machining techniques. Safety practices when working with hand tools and operating machine tools.	Remember
CO 2	Understand the concepts of Engineering Drawing & Standard Practice to be adopted in Engineering Drawing and use of various machining tools. Understand integral parts of lathe, shaping and milling machines and various accessories and attachments used.	Understand

CO 3	Hands on experience and skills for various cutting, turning operations, milling operations, forging and welding.	Apply
CO4	Analyze, identify/control appropriate process parameters and possible defects of manufacturing processes so as to reduce/ remove them.	Analyse
CO5	Enhancing the skills in machining operations like cutting, filing, turning, milling and welding. Skills in Reading and Interpretation of Engineering Drawings	Skill

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	
CO2	✓		✓		
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	

Semester - VI

Course Code: PHY321 **Course Title: MATHEMATICAL PHYSICS - II**		**Theory**	**Credits 4**
Unit -1	Complex Numbers and their Graphical Representation. Euler's formula, De-Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Equations. Examples of analytic functions. Sequence and series of		Hours 12

	functions, convergence tests, absolute and uniform convergence, Taylor and Laurent series, analytic continuation	
Unit -2	Singularities: poles, removable singularity, essential singularity, branch points, branch cut. Integration of a function of a complex variable. Cauchy's Integral formula. Simply and multiply connected region. Residues and Residue Theorem. Application of Contour Integration in solving Integrals. Evaluation of inverse Laplace transform using counter integration	12
Unit -3	Special Functions: Legendre, Hermite, Laguerre function – Generating function, Recurrence relations and their differential equations Orthogonality of eigenfunctions Bessels's function of first kind , Spherical Bessel function, Associated Legendre function, Spherical harmonics.	12
Unit -4	Fourier series, orthogonality of functions, Dirichlet conditions. Application: Summing of Infinite Series. Fourier integral theorem, Fourier transform, Parseval's identity, convolution theorem, transform of derivates, Fourier transforms of simple function occurring in physical application. Laplace Transform (LT) of Elementary functions. Properties of LTs- Change of Scale, Shifting. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations, Coupled differential equations of 1st order.	14
Unit -5	Probability and statistics: Independent and dependent events, Conditional Probability. Bayes' Theorem, Independent random variables, Probability distribution functions, special distributions: Binomial, Poisson and Normal, moment generating functions, central limit theorem, maximum likelihood, confidence intervals for Normal distribution.	10

Course Outcomes

	Course Outcome	**Level**
CO 1	To get an idea of complex variables and its uses in physical problems.	Remember, Understand,Skill
CO 2	Learn the techniques of Fourier Series and Fourier transform	Understand,Skill
CO 3	To apply the idea of Fourier Series and transform in various branches of Physics, Chemistry, Finance etc.	Understand, Analyze, Apply
CO4	Learn Laplace transformation technique and its application	Understand, Analyze, Apply
CO5	Learn statistical methods and techniques	Skill

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize,Tabulate, State, Repeat
Understand – demonstration ofcomprehension	Translate, Interpret, Extrapolate, Define in your ownwords, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a newcontext	Employ, Illustrate, Use, Solve
Analyze – supporting assertions throughthe use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test,Distinguish
Evaluate – coming to a judgement on thevalue of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come tonew conclusions	Assemble, Construct, Develop, Formulate, Propose,Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓		
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	

Course Code: PHY 322 **Course Title: Quantum Mechanics - I**		**Theory**	**Credits 4**
Unit -1	Basic principles of quantum mechanics, Properties of Wave Function. Interpretation of Wave Function: Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Position, momentum and Energy operators; Expectation values of position and momentum. Time dependent Schrodinger equation and dynamical evolution of a quantum state; Wave Function of a Free Particle, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.		Hours* 12
Unit -2	Abstract formulation of Quantum Mechanics: Dirac's bra and ket notation, linear vector spaces, Orthonormality, completeness, closure, Matrix representation of operators, basis sets. Position and momentum representations – connection with wave mechanics.		**12**

	Commuting operators. Generalised uncertainty principle. Change of basis and unitary transformation. Expectation values. Ehrenfest theorem.	
Unit -3	Generators for energy, linear and angular momentum; time independent and dependent Schrodinger equation, one dimensional potential problems: Particle in a box, Potential barriers, Tunneling. Linear harmonic oscillator: wave function approach and operator approach. Motion in three dimensions. Spherically symmetric potential problem. Orbital angular momentum operators, Spherical harmonics.	**12**
Unit -4	Quantum Dynamics: Schrodinger picture. Heisenberg picture. Heisenberg equation of motion. General view of symmetries and conservation laws. Symmetries in Quantum Mechanics: Hydrogen-like atoms and spherical harmonics. Density matrices: properties, pure and mixed density matrices, expectation value of an observable in terms of density matrix, time-evolution.	**12**
Unit -5	Angular Momentum: Commutation relations of angular momentum operators. Eigenvalues, eigenvectors. Raising and lowering operators and their matrix representations. Spin, total angular momentum; angular momentum algebra; Spin-orbit coupling: L-S and j-j coupling.	**12**

Course Outcomes

	Course Outcome	**Level**
CO 1	Understand basic concepts of Quantum mechanics,	Remember, Understand
CO 2	Develop the abstract formulation of quantum mechanics and connection with wave mechanics.	Apply, Understand
CO 3	Applying the Quantum mechanics concepts to solve one, two and three dimensional problems.	Apply
CO4	General view of symmetries and conservation laws Quantum Mechanics	Understandand Apply
CO5	Concept of spin and angular momentum algebra.	Understand, Apply, Analyse

General Objectives	**Specific Objectives**
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve

Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2	✓	✓	✓		
CO3	✓	✓	✓	✓	
CO4	✓	✓			
CO5	✓	✓			

Course Code: PHY323 **Course Title: ELECTROMAGNETIC THEORY**		**Theory**	**Credits 4**
Unit -1	Special techniques for solving electrostatics problems – Recap of Coulomb's law, Gauss law, method of images, Laplace and Poisson equation, uniqueness theorem. Maxwell's equations in vacuum and media, (differential and integral forms), wave equation, Equation of continuity of current, Displacement current, Poynting vector, energy density in electromagnetic field	Hours* 12	
Unit -2	Vector and Scalar Potentials, multipole expansion (also as special technique for electrostatics). Gauge Transformations: Lorentz and Coulomb Gauge. Poynting's Theorem and Poynting's Vector. EM Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. Review of Special Theory of Relativity and application of EMT, four vectors, transformation properties of E and B fields	**12**	
Unit -3	Wave equation – Electromagnetic waves in vacuum and matter, monochromatic plane waves, plane waves and their propagation – reflection and transmission and Snell's law, Fresnel's equations, , total internal reflection , waves in conductors – skin depth, reflection at a conducting surface, absorption and dispersion, frequency dependence of permittivity, Cauchy's formula,.	**12**	
Unit -4	Waveguides, resonant cavities and optical fibers, cylindrical cavities and waveguides, TE, TM and TEM modes, cut-off wavelength in a rectangular waveguide; Q factor of a cylindrical resonant cavity; Introduction to optical fibers – single mode and multimode; numerical aperture and angle of acceptance. Step index and graded index fibers, attenuation in fibers, couplers and connectors, fiber	**12**	

	optic communications.	
Unit -5	Relativistic charged particle dynamics in EM fields, motion of charged particle in uniform static electric field, uniform static magnetic field and crossed E and B fields. Lenard – Weichart potential, radiation from localized oscillating charge, multipole expansion, dipole radiation	**12**

Course Outcomes

	Course Outcome	**Level**
CO 1	Define terms in Electrostatics, Magnetostatics and Electromagnetism. Recall Maxwell's equations.	Remember
CO 2	The concept of Electromagnetic fields, forces and potentials. Interpret the various boundary conditions.	Understand
CO 3	Apply the concepts of electromagnetism to guided waves and fiber optics.	Apply
CO4	Analyze the motion of a charged particle under relativistic conditions and the radiation thus produced.	Analyze
CO5	Solve numerical problems related to electromagnetism, plot the field diagrams in free space and in guided waves.	Skill

General Objectives	**Specific Objectives**
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓				
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓		✓	
CO5	✓	✓	✓	✓	

Course Code: PHY324 **Course Title: Condensed Matter Physics-I**	**Theory**	**Credits 4**

Unit -1	**Chemical Bonding & Crystal Physics** Different types of bonding ionic, covalent, metallic, van der Wall's. and hydrogen bondeing, Lattice energy - Madelung constants – Born	Hours* 12

	Haber cycle – cohesive energy. Crystalline and amorphous solids, primitive and unit cells, Bravais lattices, crystal structure, lattice and basis. packing factors – cubic, hexagonal, diamond structures Lattice translation operation. Elementary idea of point symmetry operations (inversion centre, rotation and reflection symmetry). lattice planes – Miller indices for directions and planes. Reciprocal lattice. Geometrical interpretationof the Bragg equation in the reciprocal space. Bragg's law and Bragg's law, Ewald's construction, Debye Scherer method, Structural characterization using XRD.	
Unit -2	**Lattice Dynamics and Phonons** Lattice Vibrations: Vibration modes of continuous medium; concept of Phonons; Phonon dispersion relation – Localised modes, Lattice specific heat; Mono atomic and diatomic lattices – harmonic approximation - phonon frequencies and density of states Classical theory, Einstein's theory and Debye's theory of specific heat.– anharmonic effects - thermal expansion - thermal conductivity - normal and Umklapp processes - scattering experiments.	**12**
Unit -3	**The Free Electron Theory** Thermionic emission , work function , electrical conductivity of the free electron gas: Classical free electron theory (Drude model) and its draw back; Drude Lorentz Model, Sommerfield's quantum theory. the heat-capacity of the conduction electrons (Electron Specific heat).: Schrodinger's wave equations and its applications in particle in box; Physical significance of wave function;. Thermal conductivity in metals - Boltzmann transport theory - Widemann-Franz law and its validity. Failure of the free electron model.	**12**
Unit -4	**Energy Bands in Solids** Electrons in periodic potential, Origin of energy bands in solids, classification of solids as metals , insulators and semiconductors on the basis of the band picture, Origin of the energy gap, Bloch's theorem in one dimension, nearly free electron approximation - formation of energy bands and gaps - Brillouin zones and boundaries - the Kronig-Penney model. E-K diagram , Reduced zone representation ,Brillouin zone ,concept of effective mass and holes, Fermi- Dirac distribution function, Density of states for electrons in band. temperature dependence of Fermi energy, Concept of holes and effective mass; Hall Effect, Fermi surface -Cyclotron resonance. Types of semiconductors: intrinsic and extrinsic semiconductors.	**12**

Unit -5	**Magnetism, Dielectrics & Superconductivity** Electron spin and magnetic moment; Origin of magnetism; Types of Magnetism: Dia, para, ferro, ferri, and antiferromagnetism; Langevin theory of Dia and paramagnetism, Curie's law; Magnetic domains & hysteresis, Magnetic materials, Magnetic storage devices, Memory materials. Concepts of dielectrics, Dipole moment; Basic concepts and types of polarization, A.C. effects, Ferroelectricity, Piezo electricity, Ferro and piezo electric materials. Superconductors' critical parameters – anomalous characteristics persistent current, Meissner effect, Type-I & II super- conductors, BCS pairing mechanism Josephson effect, electronic specific heat in superconducting state - Energy gap and Isotope effect -London equation – Coherence length – Single particle tunneling - SQUID - High temperature superconductors - applications.	**12**
	Tasks and Assignments: **Books recommended:** 1. Elementary solid state physics, M.Ali Omar – Pearson Education (2002) 2. Charles Kittel.,“ Introduction to Solid State Physics”, John Wiley, (2019) 3. Neil W.Ashcroft and N. David Mermin, Solid State Physics, India edition IE, Thomsom books, Reprint, 2007 4. S. O. Pillai,“ Solid state physics”, New age International Pvt Ltd, 6th edition, 2005 5. Wahab, M. A.,“ Solid State Physics”, Narosa Publishing, 2nd Edition, 2005 6. Solid State Physics - D. L. Bhattacharyya (Calcutta Book House) (1990) **Supplementary Reading:** 7. Harald Ibach and Hans Lueth, Solid State Physics, 2nd edition Springer (1996) 8. H.P.Myers, Introductory Solid State Physics, 2nd edition, Viva Books Pvt. Ltd (1998) 9. M.Ali Omar, Elementary Solid State Physics, revised printing Pearson Education (2000) 10. M.S. Rogalski and S.B. Palmer, Solid Statae Physics, Gordon Breach Science Publishers (2000) 11. Y.K. Lim, Problems and solutions on Solid State Physics, World Scientific (2003) 12. A.J.Dekkar, Electrical Engineering Materials, Pearson Ed.1, 2015 13. Ibach, Harald, Lüth, Hans,Solid State Physics:An Introduction to principles of Materials Science”, Springer,4 Ed (2009). 14. James D. Patterson, Bernard C. Bailey, Solid State Physics: Introduction to the theory”, Springer-Verlag, edition 3, 2019 15. A.R.Verma and O.N.Srivastava: Crystallography Applied to Solid State Physics (1991)	

Course Outcomes

	Course Outcome	Level
CO 1	To get knowledge about various aspects of chemical bonding and understand the formation of solids with various crystal structures and symmetries. Apply the knowledge to resolve the crystal structure of solids through XRD and structural characterization tools.	Acquire, Understand, Apply, Skill
CO 2	Understand the concept of phonons and their role on specific heat of solids. Apply the knowledge to analyze the phonon dispersion relation for simple solids. Gain insight into the origin of thermal conductivity, thermal expansion though phonon scattering processes.	Remember, Evaluate, Analyse, Skill
CO 3	Understand the electron dynamics in metals through simple concepts and apply it to understand electronic and thermal conductivity in solids. Gain knowledge about wave functions and apply the electronic heat capacity, Hall effect etc.	Remember, Understand, Analyse, Apply
CO4	Analyse the electron dispersion relation in periodic potential and understand the origin of electronic bands. Distinguish insulators, semiconductors, and metals through their band structure and density of states. Explain Hall effect, effective mass, electronic specific heat etc. through band picture.	Acquire, Understand, Apply, Skill
CO5	Gain knowledge about the origin of magnetism, ordering of magnetism, and various theory involved in understanding magnetism in solids. Understand the concept of electronic polarization and its role on piezoelectricity and ferroelectricity. Analyse the role of electron phonon coupling on superconductivity and understand various aspects of superconductivity includinghigh Tc superconductors.	Understand, Analyse Apply,

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize

Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	✓
CO2	✓	✓			✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓			✓
CO5	✓	✓	✓	✓	✓

Course Code: PHY325 **Course Title: Physics Laboratory VII (Condensed Matter Physics)**	**Practical**	**Credits 2**
1	Calculation of Unit cell parameters using X-ray diffraction method	Hours 3
2	Guoy's Balance experiment for the determination of susceptibility of solids	**3**
3	Determination of dielectric permittivity of solids	**3**
4	Hall effect	**3**
5	Measurement of thermal diffusivity	**3**
6	Measurement of DC/AC conductivity of solid samples	**3**
7	Determination of band gap of a solid/semiconductor	**3**
8	Study of solar cell characteristics	**3**
9	Thermal and Electrical conductivity of metals	
10	Experimental analysis of flat plate collector of solar water heater	**3**

Course Outcomes

	Course Outcome	**Level**
CO 1	Identification of crystal structure of solids	Remember
CO2	Prediction of the thermal and electrical properties of solids and explanation of their origin	Understand
CO3	Estimation of band gap, charge carriers type and carrier concentration in solids	Apply
CO4	Demonstration of Dielectric and DC/AC conductivities of insulators	Analyse
CO5	Able to convert solar energy into electrical and thermal energy	Apply

General Objectives	**Specific Objectives**
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate

Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			
CO2	✓	✓		✓	✓
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓		
CO5	✓	✓	✓	✓	✓

Course Code: PHY411 **Course Title: Quantum Mechanics II**	**Theory**	**Credits 4**
Unit -1	**Approximation methods for stationary systems** : Time – independent perturbation theory : (a) Non–degenerate and (b) Degenerate perturbation theory, application to Zeeman effect, fine structure, helium atom and anharmonic oscillator, Isotopic shift and Stark effect, WKB approximation, Variational method and their applications.	Hours* 12
Unit -2	**Time-dependent perturbation theory:**, Time-dependent perturbation theory, Transition to a continuum of final states – Fermi's Golden rule. First order correction – Semiclassical radiation theory, interaction between electromagnetic wave and atoms – transition probabilities - radiation field quantization, polarizability of a system, Photo-electric effect, Einstein's coefficients – selection rules for harmonic oscillator and hydrogen atom., Adiabatic and sudden approximations, Spontaneous emission, absorption, induced emission, dipole transitions, selection rules.	**12**
Unit -3	**Symmetries:** Construction of wave functions for a system of identical particles. Bosons and Fermions; symmetric and anti-symmetric wave functions; Pauli principle. Symmetry- Galilean invariance; Translation and Rotation operation; Parity and time reversal; Wave function for time, space translation and rotation;	**12**
Unit -4	**Scattering:** Non-relativistic scattering, solution of scattering problem by the method of partial wave analysis, optical theorem, Scattering Amplitude - Expression in terms of Green's Function - Born approximation and its validity for scattering problems, Interaction with classical radiation fields; Rayleigh scattering - Scattering theory- Scattaring cross section, Phase Shifts - Scattering by coulomb and Yukawa Potential.	**12**

Unit -5	**Relativistic Quantum Mechanics:** Dirac equation: Motivation for Dirac equation, Properties of Dirac matrices, positive and negative energy states, Plane wave solution of Dirac equation. Spin of Dirac particle - Spin wave function of Dirac particle and Magnetic moment. Introduction to Quantum Field Theory, Second Quantization of Schrodinger Equation.	**12**
	Tasks and Assignments: **References:** 3. Mathews P M and Venkatesan K, "A Text book of Quantum Mechanics", Tata Mc Graw- Hill, New Delhi. 1976. 4. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education, 2005. 5. Liboff, Introdunctory Quntum Mechanics, Narosa Publishing House. 6. Quantum Mechanics – Zettli	

Course Outcomes

	Course Outcome	Level
CO 1	Finding the energy levels of quantum systems subject to time independent perturbations.	Understand
CO 2	Applying the concept of time dependent perturbation theory to study atom-light interactions.	Apply
CO 3	Analyze the quantum scattering of identical particles and find the cross section for scattering.	Analyze
CO4	Solve problems related to perturbation theory, identical particles, and scattering theory in quantum mechanics.	Skill

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓			✓	✓
CO2	✓			✓	✓
CO3	✓			✓	✓
CO4	✓			✓	✓

Course Code: PHY412 Course Title: Atomic and Molecular Physics		Theory	Credits 4
Unit -1	Atomic units, Schrödinger equation of one electron system: length and energy scales for its applicability, Solution of the angular equation: spherical harmonics, angular momentum, magnetic moment of atoms, Stern-Gerlach experiment, space quantization; Solution of the radial equation: energy quantization, radial distribution function, Expectation values, Various angular momentum basis states of hydrogen atom, Spectral lines, Special hydrogenic systems: muonium, positronium, Rydberg atoms.		Hours 12
Unit -2	Fine structurs of Hydrogen atom, Welton-Weisskopf model for the Lamb shift, Hyperfine structures and isotope shifts, selection rules for transition, Zeeman effect, Stark effect; Ground state of Helium, excited states of Helium, Pauli's anti-symmetric principle and Slater determinant, Shell and subshell structure of many electron atoms, central field approximation, Alkali atoms and quantum defect, Corrections to central field approximations, L-S coupling, atomic term symbol, fine structure in the L-S coupling scheme, j-j coupling.		14
Unit -3	Energy scales and length scales in molecules, Born-Oppenheimer approximation, Molecular orbital approximation, Heitler–London method; Electronic states of diatomic molecules: electron configurations and molecular ground states, excited molecular states, excimers; Physical Reasons for Molecular Binding: covalent bond, multipole interaction, van der Waals interaction, Morse potential;		12
Unit -4	Rotation of diatomic molecules: rigid rotor, centrifugal distortion, Vibration of diatomic molecule, Interaction between rotation and vibration, Spectra of diatomic molecules: P,Q, R branches, determination of band origin, band intensities, FranckCondon principle.		10
Unit -5	Microwave Spectroscopy, Infrared Spectroscopy, Raman Spectroscopy, Laser Spectroscopy, and Electron Spectroscopy.		12
	References: 1. *Physics of Atoms and Molecules*, B. H. Bransden and C. J. Joachain (Longman Scientific & Technical Group Ltd.) 2. *Atoms, Molecules and Photons*, Wolfgang Demtroder (Springer) 3. *Atomic Physics*, C. J. Foot (Oxford University Press) 4. Atomic and Molecular Spectroscopy, Sune Svanberg (Springer) 5. Fundamentals of Molecular Spectroscopy, C. N. Banwell (McGraw-Hill Book Company)		

Course Outcomes

	Course Outcome	Level
CO 1	Learning techniques to solve Schrodinger equation for spherically symmetric potential, using Spherical Harmonics, understanding basic atomic structure	Remember Apply Understand
CO 2	Understanding full atomic structure for atoms with one and many electrons, application of perturbation theory, application of angular momentum algebra	Understand Apply
CO 3	Understanding formation of molecules and their stability, learning electronic structure of di-atomic molecules	Understand
CO4	Learning about various motion of a molecule and its effect on the energy level	Understand
CO5	Learning various spectroscopic techniques	Apply Skill

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓		✓	✓
CO4	✓	✓		✓	✓
CO5	✓	✓	✓	✓	✓

Course Code: PHY413 **Course Title: Statistical Mechanics**		**Theory**	**Credits 4**
Unit -1	Introduction: Microstates and macrostates- phase space and volume in phase space, density distribution in Phase space, Phase space evolution. Conditions for equilibrium. Different thermodynamic systems and concepts of ensemble. Time average and ensemble average; Ergodic theory. Microcanonical ensemble : Hypothesis of equal a priori probability, Boltzmann entropy; Statistical definition of temperature, pressure, and chemical potential. partition functions and properties, calculation of thermodynamic quantities, perfect gas in micro canonical ensemble; Gibbs Paradox; Sackur-Tetrode equation; correct enumeration of microstates. practical implication of microcanonical ensemble. Derivation of ideal and slightly non ideal gas equation.	Hours **16**	
Unit -2	Canonical ensemble: Equilibrium between a system and a heat reservoir; Gibb's canonical entropy, energy fluctuations in the canonical ensemble; derivation of equipartition theorem, ideal and slightly non ideal gas equation; application: a system of Harmonics oscillator; statistics of paramagnetism.	**12**	
Unit -3	Grand canonical ensemble: Partition functions and properties, calculation of thermodynamic quantities, density and energy fluctuations. Various thermodynamic potentials and their connection with partition functions. Maxwell-Boltzmann (MB) distribution law: Derivation. Calculation of thermodynamic quantities for ideal monatomic gases. Equivalence of ensemble.	**12**	
Unit -4	Quantum Statistics: Bose-Einstein (BE) Statistics, Fermi-Dirac (FD) Statistics, examples illustrating counting procedures for MB, BE and FD statistics and derivation; Entropy maximization; Thermodynamics interpretation of Lagrange's undetermined multiplier; Comparison between the three statistics. Conditions under which the quantum mechanical distribution functions reduce to the classical MB distribution. Thermodynamic behaviour of Bosons and Fermions; Black body radiation and Planck's radiation; Bose-Einstein condensation (qualitative discussion); Fermi distribution at zero and nonzero temperatures.	**12**	
Unit -5	Brownian Motion: Fluctuation, Einstein theory of Brownian motion, diffusion coefficient; Langevin theory (qualitative discussion); Fluctuation-dissipation theorem; random walks and self avoiding walks.	**8**	
	Tasks and Assignments: **References:** 1. Statistical Mechanics: K. Huang (John Wiley and Sons). 2. Fundamentals of Statistical and Thermal Physics, F. Reif, (Mc Graw Hill) 3. Statistical Mechanics by Pathria – Elsevier.		

Course Outcomes

	Course Outcome	Level
CO 1	Understand concept of ensemble	Understand
CO 2	Applying the ensemble concepts to open, closed thermodynamics system.	Apply
CO 3	Examine the concept of equivalence of ensemble.	Analyze
CO4	Solve different thermodynamics systems by using classical and quantum statistics	Skill
CO5	Find out the application of ensemble concept in diffusive systems.	Evaluate

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓			✓	✓
CO2	✓			✓	✓
CO3	✓			✓	✓
CO4	✓	✓		✓	✓
CO5	✓	✓			

Course Code: PHY414, **Course Title: Physics Laboratory VIII (Atomic and Optics)**	**Practical**	**Credits: 2**
	1. Abbes Refract meter- To Study the variation of RI with temperature of different liquid. 2. Half shade Polari meter- Determination the specific Rotation of given solution. 3. GM counting system- 4. Diffraction due to Helical Structure 5. Optical Characterization of given Solid/Thin film Liquid by UV 6. Fourier Transform Infrared Spectroscopy 7. Raman Spectroscopy	

	8. X-ray photoelectron spectroscopy	
	Tasks and Assignments: 1. Virtually executing the experiments 2. Observation submission 3. Viva-Voce 4. Practical Examination **References:** 1. Virtual labs, https://www.vlab.co.in/ 2. Brijlal and Subramaniam, "Electricity and Magnetism", Ratan Prahasan Mardis Educational and University Publishers, Delhi, 1990 3. Jacob Millman and Christos C Halkias, "Electronic Devices and Circuits", Tata McGraw Hill Edition, 1991.	

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
PSO1	x	x		x	x	x
PSO2	x	x		x	x	x
PSO3	x	X		x	x	x
PSO4	x	x		x	x	x
PSO5	x	x		x	x	x

Course Code: PHY451 **Course Title: ELECTRONICS**		**Theory**	**Credits 4**
Unit -1	Semiconductor diodes: Construction, working principle and I-V characteristics of p-n junction diode, device performance as rectifier (Half-wave and Full-wave rectifiers) , voltage regulator, application of P-N junction as solar cel; Construction and I-V characteristics, Schockley diode, Zener, Avalanche, Schottky-barrier diode and Tunnel diodes, LED and photodiodes	Hours* 12	
Unit -2	Construction, operation and Characteristics of BJT, UJT, FET, MOSFET and CMOS configuration. BJT as an amplifier; negative and positive feedback circuits; Oscillators: Hartley and Colpitt oscillators; Power Amplifiers: Class A, B, AB and C; voltage, current and power amplifiers	**12**	
Unit -3	OPAMP - Basics of differential amplifiers-Characteristics of ideal and practical opamps-Applications; inverting, non-inverting, Summing, difference, integrating, differentiating amplifiers. Active filter circuits: Low-pass, High-pass, Band-pass, Band-stop	**12**	
Unit -4	Introduction to elements of Boolean algebra, AND, OR, NOT, NAND, NOR, XOR and XNOR logics. Combinational circuits: Adders, subtractors, multiplexer/demultiplexer, decoder and encoders-Flip Flops; S-R, J-K, counters- synchronous, asynchronous, Modulo-n-counters-shift registers; Serial to parallel and vice-versa, universal shift registers, ring counter. A/D and D/A converters	**12**	

Unit -5	Microprocessor: Introduction, components, sysytem bus, 8085 microprocessor architecture; Instruction set and assembler directives, I/O interfacing	**12**
	Tasks and Assignments: **References:**	

Course Outcomes

	Course Outcome	Level
CO 1	Learning of operational principle, construction and output characteristics of diodes, Transistors and Op-amp.	Remember
CO 2	Differentiation of different diodes through their I-V characteristics	Understand
CO 3	Designing of half wave and full wave rectifiers with diodes; amplifiers and oscillators with transistors and op-amps, construction of active filters with op-amps	Apply
CO4	Illustration of logic gates and verification of truth tables	Analyze
CO5	Design and analyse combinational and sequential logic circuits	Skill
CO6	Assembly programming(addition/subtraction) using 8085 microprocessor	Understand

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓				
CO2	✓	✓		✓	
CO3	✓	✓	✓		✓
CO4	✓	✓		✓	
CO5	✓	✓	✓	✓	
CO6	✓	✓			✓

Course Code: PHY452 Course Title: Physics Laboratory-IX (ELECTRONICS)	Practical	Credits 2

Preliminary experiments	Study of CRO fundamentals IV characteristics of a junction diode	3
1	Study of IV characteristics of a zener diode and voltage regulation by zener diode.	**3**
2	Half wave, full wave and bridge rectifier using diodes.	**3**
3	A study of Transistor Characteristics (a) CB, (b) CE and (c) CC.	**3**
4	Studies on BJT CE amplifier	**3**
5	Colpitt's oscillators	**3**
6	Characteristics of MOSFET.	**3**
7	Voltage regulator using IC 7805	**3**
8	Construction of Logic Gates: AND, OR, NOT using Transistor	**3**
9	Flipflops: RS, JK	**3**
10	Operational amplifier: Summing, Inverting, , Differentiator , Integrator	**3**
11	Assembly programming(addition/substration) using 8085 microprocessor	**3**

Course Outcomes

	Course Outcome	**Level**
CO 1	Understanding the output characteristics of P-N junction and Zenor diodes	Remember
CO 2	Study of output characteristics of transistors in different configuration & MOSFET	Understand
CO 3	Demonstration of voltage regulator using Zenor diodes & IC 7805, Construction of rectifiers, amplifiers and Oscillators	Apply
CO4	Construction of logic gates; flip-flops	Analyze
CO5	Application of Operational amplifier: Summing, Inverting, & programming using 8085 microprocessor	Skill

General Objectives	**Specific Objectives**
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓			
CO2		✓			
CO3	✓	✓		✓	
CO4	✓	✓		✓	
CO5	✓	✓			✓

Semester VIII

Course code: PHY421 **Course Title: Modern Optics**		**Theory**	**Credits 4**
Unit -1	Origin and mathematical construct of traveling waves, thedifferential wave equation, representation of waves, harmonic waves,idealized waveforms: spherical waves, cylindrical waves, plane waves, Electromagnetic wave, Fresnel equations, reflectance and transmittance, total internal reflection, Evanescent wave,frustrated total internal reflection, Polarization of light, Production of polarized light, Nicol prism, Rochon and Wollaston prism, Wave-plates, Optical activity, Fresnel's explanation of rotation.		Hours **12**
Unit -2	Superposition of coherent and incoherent waves, phase velocity and group velocity, Interference of light, Conditions for interference, Young's double-slit experiment, Fringes of equal inclination, Fringes of equal thickness, The Michelson interferometer, Multiple beam interference, Fabry-Perot interferometer, etalon.		**12**
Unit -3	Diffraction of light, Huygens-Fresnel principle, Fraunhofer diffraction: froma single slit, circular apertures, double slits, many slits, The diffraction grating, resolution of imaging systems, Fresnel's half-period zones, zone-plate, Fresnel diffraction from a circular aperture, opaque disc; near-field diffraction of straight edge and single slit using Cornu's spiral.		**14**
Unit -4	Fourier series, wavepackets, Fourier transform, The lens as a Fourier transformer, Coherence Time and Line width via Fourier Analysis, Spatial Coherence and Temporal Coherence, Fourier methods in Fraunhofer diffraction, Spectra, Convolution and Correlation of optical pulses.		**10**
Unit -5	Response of non-linear optical medium, nonlinear polarization, classical origin of nonlinear susceptibility, waves in nonlinear medium, second harmonic generation, sum-frequency generation, parametric oscillation, parametric Amplification, self-focusing; Quantization of electromagnetic field in a cavity, Fock states of radiation field, quadrature operators, squeezed light, photon statistics, mechanical effects of light - laser cooling and trapping of atoms, principle of complementarity, quantum erasure		**12**
	References: 1. *Optics*, Eugene Hecht (Addison Wesley) 2. *Fundamentals of Optics*, F. A. Jenkins & H. E. White (McGraw-Hill Primls Custom Publishing) 3. *Optics*, Ajoy Ghatak, (Tata McGraw Hill) 4. *Nonlinear Optics*, R. W. Boyd (Academic Press) 5. *Quantum Optics - An Introduction*, Mark Fox (Oxford University Press)		

Course Outcomes

	Course Outcome	Level
CO 1	Understanding general characteristic of traveling waves and establishing light as a transverse electromagnetic wave	Remember
CO 2	Understanding interference phenomena and its application in various optical devices	Understand Apply Skill
CO 3	Understanding diffraction effects and practicality of the usage of various imaging devices as well as spectrometers	Understand Apply Skill
CO4	Learning Fourier method to solve various optical problems	Apply Skill
CO5	Learning beyond the conventional wave optics	Understand

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓				✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓		✓	✓
CO5	✓	✓	✓	✓	✓

Course Code: PHY422 **Course Title: Nuclear and Particle Physics**	**Theory**	**Credits** **4**
Unit -1	Brief Introduction to proton, neutron discovery, properties of strong nuclear force, units used in nuclear physics, Bulk Properties of Nuclei: Nuclear mass, charge, size, Isobar, isotope and isotones. Mass spectrometer (Bainbridge). Binding energy, binding energy per nucleon versus mass number curve and its characteristics.	12 Hours
Unit -2	Nuclear stability, binding energy of the nucleus, qualitative description of the liquid drop model of the nucleus, Bethe•-Weizsacker mass formula (only statement and explanation of the terms in the formula), extreme independent shell model of the nucleus and its predictions for magic numbers and ground state spin parity of the nucleus, spin and magnetic, electric quadrupole moment. Parity, Sub•barrier fusion, symmetries in nuclei, Quantum Mechanical features of nuclear system.	12 Hours
Unit -3	Radioactivity: alpha, beta and gamma rays, velocity and energy of alpha particles, Geiger• Nuttal law, Beta decay, nature of beta ray spectra, neutrinos and positrons, inverse beta decay, range and strength of weak force, half•-life and decay rate of radioactive elements, radioactive series. Interaction of nuclear radiation with matter, description of detectors: Gas detector, silicon and scintillation counters.	12 Hours
Unit -4	Qualitative Approach to Nuclear Reactions: Conservation principles in nuclear reactions, Threshold energy, nuclear reaction cross •sections • Types of fission• distribution of fission products – fissile and fertile materials – neutron emission in fission – spontaneous fission • Explanation of nuclear fission using liquid drop model,	12 Hours

	fission products and energy release. Spontaneous and induced fission transuranic elements. Chain reaction • fusion• energy released – stellar energy – controlled thermonuclear reaction – plasma confinement. Reactors: Qualitative description of fission reactors, schemes for nuclear fusion, fuels, moderators, and coolants.	
Unit -5	Elementary Particles: Four basic interactions in nature and their relative strengths, examples of different types of interactions, Quantum numbers, •mass, charge, spin, isotropic spin, intrinsic parity, hypercharge, Charge conjugation. Conservation of various quantum numbers, Classification of elementary particles, hadrons and leptons, baryons and mesons, elementary idea about quark structure of hadrons, octet and decuplet families. Brief introduction to Feynman diagram.	12 Hours

Course Outcomes

	Course Outcome	Level
CO 1	Discovery of nucleus and Strong force, models of nucleus, Shell model, properties of radiation, various nuclear reactions, four fundamental forces and their properties, classification of elementary particles, symmetry and different quantum numbers.	Remember
CO 2	Shell model, Quantum mechanical treatment of nucleon system, scattering, Alpha decay, beta decay, interaction of radiation with matter, Gell-Mann's eight fold way, conservation of different quantum numbers and their relation to symmetry-Noether's theorem	Understand
CO 3	Shell model to find nuclear spin, magnetic moment and electrical quadrupole moments of various nuclei. Apply quantum mechanics to solve alpha-decay and beta-decay process, also to understand nuclear reactions. Theory of interaction of radiation with matter to understand the working principle of radiation detectors. Conservation of various quantum numbers to understand three fundamental forces.	Apply
CO4	Liquid drop models give a very simple idea to model a system and explain its properties. Deuteron problem is helpful to solve quantum mechanical systems, and finding out scattering cross sections, solving kinematic problems related to particle decay using invariant mass methods.	Skill

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

Course Code: PHY461 **Course Title: Laser Physics**	**Theory**	**Credits 4**
Unit -1	**Principles of Lasers:** Interaction of radiation with matter – Absorption, spontaneous and stimulated emission – Einstein coefficients – relation between spontaneous and stimulated emmision rates, Light amplification – Threshold condition for laser action, Line broadening mechanisms – Natural, Collision and	Hours* 12

	Doppler broadening. Laser operations – Two level system, Population inversion in three level and four level systems-Threshold pump power, relative merits and de-merits of three and four level system.	
Unit -2	**Laser Types** - Mathematical description of Gaussian beams using Maxwell's equations. Propagation of Gaussian beams through optical elements. ABCD law for Gaussian beams. Hermite-Gaussian beams. Laser Systems - Gas lasers: He-Ne laser, Carbondioxide laser, Nitrogen gas laser, Argon ion gas laser – Solid state lasers: Ruby laser, Nd-YAG laser, Dye lasers - Optically pumped laser systems	**12**
Unit -3	**Laser Operations:** Resonant cavities, modes of a rectangular cavity, quality factor of an optical resonator, ultimate laser line width , Longitudinal and Transverse mode selection, Pulsed lasers - Q-switching and Mode locking concepts and techniques. - Resonator configurations - Stability of resonators, - Characteristics of Gaussian beam.	**12**
Unit -4	**Fiber Lasers:** Erbium doped fiber laser – basic equations for amplification and its steady state solutions, derivation for doped fiber length, threshold pump power and laser output power, Erbium doped fiber amplifier, mode locking using non-linear polarization, semiconductor lasers, optical gain in semiconductors, density of states, interaction of semiconductor with light, light amplifcation and gain coefficient in semiconductors, Quasi-Fermi levels, Gain in diode laser, Quantum-Well lasers – derivation for gain coefficient.	**12**
Unit -5	**Laser Applications:** Holography , Basic Principle – Holographic interferometry – Speckle Metrology, Material processing- welding, cutting, and drilling. laser tracking, pollution monitoring using lasers, lasers in isotope separation, lasers in precision length measurement, lasers in information storage, bar-code scanner, Biological and Medical applications of lasers.	**12**
	Tasks and Assignments: **References:** 1. Lasers Theory and Applications: K. Thyagarajan and A.K. Ghatak (McMillan). 2. C.O. Shea, W.R. Callen and N.T. Rhodes, "An Introduction to Lasers and their Applications"', Addison Wesley, 1969. 3. J. Verdeyen, 'Laser Electronics', Second Edition, Prentice Hall, 1990. 4. Goldman and Rockwell, 'Lasers in Medicine', Gordon and Breach, New York, 1985. 5. B.B. Laud, 'Laser and Non-Linear Optics', Second Edition, New Age International (p) Limited publishers, 1996. 6. Optics and Atomic Physics – B. P. Khandelwal (Siblal Agarwala). 7. Optical Electronic – A. K. Ghatak and K. Tyagrajan. 8. Introduction to Fibre Optics - R. A. Shotwell (EEE, Prentice Hall).	

Course Outcomes

	Course Outcome	**Level**
CO 1	Define basic radiation phenomena in atoms such as spontaneous and stimulated emissions, and absorption of radiation.	Remember
CO 2	The concept of laser operation and derivation of threshold condition for laser oscillation.	Understand
CO 3	Apply the ideas of Q-switching and mode locking concepts for producing laser pulses.	Apply
CO4	Analyze the operation of fiber and semiconductor lasers for light amplification	Analyze

CO5	Get knowledge to focus lasers for optical experiments in laboratory.	Skill

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓			✓	✓
CO2	✓	✓		✓	✓
CO3	✓	✓		✓	✓
CO4	✓			✓	✓
CO5	✓	✓		✓	✓

Course Code: PHY462 **Course Title : Physics Laboratory -X (Laser Physics)**		**Practical**	**Credits: 2**
	1) Diffraction due to surface tension waves on water. 2) Diffraction due to helical structure. 3) Laser beam characteristics a) Beam waist b) Intensity profile 4) a) Determination of laser parameter-divergences and wavelength for a given laser source using grating. (b) Particle size determination. 5) Fibre optics characterisation-To find numerical aperture of single mode fibre and losses. 6) Brewster's Angle experiment to find refractive index. 7) Polarization of Laser (Verification of Malus Law). 8) Light Intensity Vs Distance using by light source. 9) Interference and Diffraction through slit.		
	Tasks and Assignments: 1. Virtually executing the experiments 2. Observation submission 3. Viva-Voce 4. Practical Examination **References:**		

	1. Optical Fibre Communications: G. Keiser (Tata McGraw Hill). 2. Application of lasers, John F. Ready. 3. Principles of lasers, Fourth edition-by Orazio Svelto

Course Outcomes

	Course Outcome	Level
CO 1	Students can understand the handling of laser light	Understand
CO 2	Students can able to use the laser light source through fiber for various applications	Apply
CO 3	Students can able to utilize the laser light to various experiments	Utilizing
CO4	Students can able to experimentally understand about the nature of light and its property changes	Experimental
CO5	Students can use this laser experimental study to the research level for laser production and characterization for advanced level applications	Research

Mapping of Program Outcomes with Course OutcomesCourse

	PO1	PO2	PO3	PO4	PO5
CO1			**x**		
CO2		**x**			
CO3	**x**				
CO4					**x**
CO5				**x**	

Code: PHY463 **Course Title: Experimental Methods and Design**	**Credits: 4**	**Theory**	**Hours**
Unit -1	Measurement of fundamental constants: e, h, c – Measurement of high and low resistances, inductance and capacitance – Detection of X-rays, Gamma rays, charged particles, neutrons – Ionization chamber – Proportional counter – GM counter – Scintillation detectors – Solid State detectors.		12
Unit -2	Emission and Absorption Spectroscopy – Measurement of Magnetic field – Hall effect – Magnetoresistance – X-ray and neutron Diffraction.		10
Unit -3	Vacuum Techniques – Basic idea of conductance, pumping speed – Pumps: Mechanical Pump – Diffusion pump – Gauges – Thermocouple gauge – Penning gauge – Pirani gauge – Hot Cathode gauge – Low temperature systems – Cooling a sample over a range up to 4 K – Measurement of low temperatures.		12
Unit -4	Measurement of energy and time using electronic signals from the detectors and associated instrumentation – Signal processing – A/D conversion – multichannel analyzers – Time-of-flight technique – Coincidence Measurements – true to chance ratio – Correlation studies. Error Analysis and Hypothesis testing – Propagation of errors – Plotting of Graph – Distributions – Least squares fitting – Criteria for goodness of fits – Chi square test.		12

Unit -5	Design of experiment – need for experiments (validation of theory/ verification of theory/ addition to database); computer interfacing; Data collection and analysis – errors and accuracy of data collected, types of errors, propagation of errors, reporting data – mean, variance, method of least Bsquares fit, central limit theorem, error bars. Data reproducibility and ethics of data collection.phase sensitive detection; shielding of cables.	14
	Tasks and Assignments: **References:** 1. J.P. Holman, Experimental Methods for Engineers. 7th Edition. McGraw Hill (2000). 2. J. M. Lafferty (Editor) (1998), Foundations of Vacuum Science and Technology, Wiley Interscience. 3. Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley(2004). **Suggested Reading:** 4. Anthony Kent, Experimental Low-Temperature Physics ,Macmillan Physical Science (1993). 5. T. G. Beckwith, R. D. Marangoni and J. H. Lienhard ,Mechanical Measurements,6th Edition(2006),Prentice Hall. 6. Ernest O Doebelin, Measurement Systems: Application and Design. 5th edition, Tata McGraw Hill. 7. Albert D Helfrick and William D Cooper (1992), Modern Electronic Instrumentation and Measurement Techniques. Prentice Hall. 8. Hermann K P Neubert, Instrument Transducers: An introduction to their performance and design. Oxford University Press(2003). 9. J. A. Blackburn Modern Instrumentation for Scientists and Engineers, Springer (2001).	

Course Outcomes

	Course Outcome	**Level**
CO 1	Different experimental techniques, need for vacuum technology, methods used in the design of experiments.	Remember
CO 2	Understand the strength and limitation of each technique and choose the right technique for characterization of properties. Understand the methods used in the design of experiments and how these methods are connected to statistical models.	Understand
CO 3	Approach complex industrial and business research problems and address them through a rigorous, statistically sound experimental strategy. Apply the analytical techniques and graphical analysis to the experimental data.	Apply
CO4	Analyze the pros and cons of applying the experimental methods to correlate with the Physics theory.	Analyse
CO5	Design simple experiments him/her self and have a general insight into how data analysis is done in connection to designed experiments.	Skill

General Objectives	**Specific Objectives**

Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			
CO2	✓	✓			
CO3	✓	✓	✓	✓	
CO4	✓	✓		✓	
CO5	✓	✓	✓	✓	

Course Code: PHY464 **Course Title: Physics laboratory-XI (Experimental Techniques)**		**Credits: 2**	**Laboratory/ Practicals**	**Hours**
	1. Measurement of resistivity of semiconductors by four probe method.			3
	2. Verify the following laws (i) AC Wheatstone bridge (ii) Maxwell's Bridge (iii) De Sauty's bridge			3
	3. Determine the optical constants of Thin film deposited on transparent substrate.			3
	4. Determine the electric dipole moment of organic molecule (Acetone)			3
	5. Determine the dielectric constant of Non polar liquid (Benzene)			3
	Repeat/ Revisit experiments			3

	6. Experimentally determine the temperature dependence of the capacitance of a ceramic capacitor	3
	7. Permittivity of dielectric materials (LCR meter)	3
	8. Measurement of High and Low Resistance	3
	9. Lock in amplifier.	3
	Repeat/ Revisit experiments	3

References:

1. B.L. Worsnop and H. T. Flint , Advanced Practical Physics, Asia Publishing House.
2. Erhan Gülmez: Advanced Physics Experiments (1999)
3. C.L. Arora, Practical physics, S. Chand Publication,
4. Daryl W. Preston and Eric R. Dietz: The Art of Experimental Physics.
5. Class materials and the references within.

Course Outcomes

	Course Outcome	Level
CO 1	Different experimental techniques, methods used in the design of experiments.	Remember
CO 2	How to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions.	Understand
CO 3	Apply the gained knowledge on the operational details of the experiments and interpret the obtained data.	Apply
CO4	Analyze the resulting data of the given experiment(s), and submit lab report at the end of every lab session.	Analyse
CO5	Able to design and carry out an experiment on his/her own, Design simple experiments him/her self and have a general insight into how data analysis is done in connection to designed experiments.	Skill

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish

Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	
CO2	✓	✓	✓		
CO3	✓		✓	✓	
CO4	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	

Semester - IX

Course Code: PHY511 **Course Title: Condensed matter physics II**	**Theory**	**Credits 4**
Unit -1	Inter and intra molecular interactions, self-assembly and self-association, correlations, formation of condensed phases, length, time and energy scales in condensed matter systems Basic phenomenology of soft condensed matter systems: phase behaviour, diffusion and flow, viscoelasticity.	Hours* **12**
Unit -2	Order Parameter, Phases and Phase transitions Mean Field theory and phase diagrams, order parameter, metastable states. Interfaces and wetting, Young's equation, solid-liquid interaction.	**12**
Unit -3	Introduction to Liquid crystals, Frank free energy, Landau de Gennes model of isotropic-nematic transition, Onsager's mean field theory, nematic-smectic transition.	**12**
Unit -4	Introduction to colloids, Poisson- Boltzmann theory, DLVO theory, sheared colloids, stability of colloidal systems, measurement of interaction.	**12**
Unit -5	Introduction to Polymers & Membranes: Model systems, chain statistics, ideal polymers, role of solvent, Equivalent Kuhn chain, mean square end-to-end- length and radius of gyration, Probability distribution in an ideal polymer, Entropic "Hook's Law", ideas of self-avoidance, rubber elasticity, viscoelasticity and reptation	**12**

Course Outcomes

	Course Outcome	Level
CO 1	Understand the origin of condensed phases and the scales involved	Understand
CO 2	Understand phase transitions and wetting	Understand
CO 3	Understand liquid crystals and apply phase transition principles to their meso phases	Understand and Apply
CO4	Analyze colloids with respect to various theories	Analyze
CO5	Analyze polymers with respect to statistical physics models	Analyze

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

Course Code: PHY551 **Course Title: Computational Physics II**		**Theory**	**Credits 4**
Unit -1	**Introduction and overview** Introduction and Basic concepts, Theoretical Background, Basic equations for interacting electrons and nuclei, Coulomb interaction in condensed matter, Independent electron approximations, Exchange and correlation, Periodic solids and electron bands, Structures of crystals: lattice + basis, The reciprocal lattice and Brillouin zone, and the Bloch theorem. Time reversal and inversion symmetries, Integration over the Brillouin zone and special points Density of states - Uniform electron gas and simple metals.	Hours 12	
Unit -2	**Introduction to quantum mechanical modeling: Hartree-Fock and Density function theory** Non-interacting and Hartree-Fock approximation, the correlation hole and energy. Density functional theory: foundations, Thomas-Fermi-Dirac approximations: example of a functional. The Hohenberg-Kohn theorems, Constrained search formulation of density functional theory, Extensions of Hohenberg-Kohn theorems, The Kohn-Sham ansatz. Replacing one problem with another: The Kohn-Sham variational equations E_{xc}, V_{xc} and the exchange correlation hole - meaning of the eigenvalue. Intricacies of exact Kohn-Sham theory.	**12**	

Unit -3	**Exchange Correlation Functionals, Correlation effects. And SCF calculations** Functionals for exchange and correlation - The local spin density approximation (LSDA), Generalized-gradient approximation (GGAs) , LDA and GGA expressions for the potential Vxc(r), Non-collinear spin density, Non-local density formulations: ADA and WDA - Orbital dependent functionals I: SIC and LDA+U. Orbital dependent functional II: OEP and EXX, Hybrid functionals -Tests of functionals Solving Kohn-Sham equations – Self-consistent coupled Kohn Sham equations - Total energy functionals - Achieving self-consistency – Numerical mixing schemes - Force and stress.	**12**
Unit -4	**Electronic structure from plane wave and localized basis methods** Determination of electronic structure – Atomic sphere approximation in solids, Plane waves and grids: basics - The independent particle Schrodinger equation in a plane wave basis. The Bloch theorem and electron bands - Nearly free-electron-approximation - Form factors and structure factors. Plane-wave method - ‘Ab initio’ pseudopotential method - Projector augmented waves (PAWs) - Simple crystals: structures, bands, - Supercells: surfaces, interfaces, phonons, defects - Clusters and molecules. Localized orbitals: tight-binding – Tight-binding bands: illustrative examples - Square lattice and CuO_2 planes - Examples of bands: semiconductors and transition metals - Electronic states of nanotubes. Localized orbitals: full calculations – Solution of Kohn-Sham equations in localized bases. Analytic basis functions: Gassians - Gassian methods: ground state and excitation energies - Numerical orbitals - Localized orbitals: total energy, force, and stress - Applications of numerical local orbital methods.	**12**
Unit -5	**Mixed Basis Methods and Their Applications** Augmented plane waves (APW’s) and ‘muffin-tins’ – Solving APW equations: examples Muffin-tin orbitals (MTOs). Linearized augmented plane waves (LAPWs) - Applications of the LAPW method - Linear muffin-tin orbital (LMTO) method - Applications of the LMTO method - Full potential in augmented methods - Molecular dynamics (MD): forces from the electrons - Lattice dynamics from electronic structure theory - Phonons and density response functions - Periodic perturbations and phonon dispersion curves - Dielectric response functions, effective charges - Electron-phonon interactions and superconductivity.	**12**

	Tasks and Assignments: **Books recommended:** 1. H.Skriver, The LMTO Methods, Springer (1984). 2. Electronic Structure Basic Theory and Practical Methods Richard M. Martin, Cambridge University Press (2004). 3. Modeling Materials Continuum, Atomistic and Multiscale Techniques ELLAD B. TADMOR, Cambridge University Press (2012). 4. Atomic and Electronic Structure of Solids, Efthimios Kaxiras, Cambridge University Press (2003). *5.* Computational Chemistry of Solid State Materials, *Richard Dronskowski*, WILEY-VCH (2005). 6. Mizutani U. Introduction to the Electron Theory of Metals (CUP,2001). 7. Roessler U. Solid State Theory.. An Introduction (2ed., Springer, 2009) **Supplementary Reading:** 2. N.W. Ashcroft and N.D.Mermin, Solid State Physics. Saunders, 2004. 4. G.C.Fletcher. Electron theory of solids. North Holland Pub. Co. 1980. 5. Density Functional Theory – D. S. Sholl and J.A. Steckel, Wiley, 2009. 6. A Primer in Density Functional Theory – C. Fiolhais, F. Nogueira, and M. Marques, Springer, 2016.

Course Outcomes

	Course Outcome	**Level**
CO 1	Introduce students to modelling of solids and predict as well as interpret their various properties using computational modelling.	Acquire, Understand,
CO 2	Show how these modelling methods can be used to understand fundamental material structure and properties as well as the relationships between material structure and material behaviour.	Evaluate, Analyse,Skill
CO 3	Develop an understanding of the assumptions and approximations that are involved in the modelling frameworks at the various time and length scales.	Remember, Understand, Analyse, Apply
CO4	Students will be introduced to the basis for the simulation techniques, learn how to use computational modelling, and how to present and interpret the results of simulations.	Understand, Apply, Skill
CO5	The students will learn various computational parameters and practical knowledge involve in modelling functional properties of solids and with that knowledge they can design materials in the computational lab for various applications.	Understand, Analyse, and Apply

Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓			✓	✓
CO2	✓	✓	✓		✓
CO3	✓		✓	✓	✓
CO4	✓	✓			✓
CO5	✓	✓	✓	✓	✓

Course Outcomes

	Course Outcome	Level
CO 1	Students can understand the fundamentals of Density Functional Theory.	Fundamental
CO 2	Students can utilize the technology to do the experiments and analyze results scientifically and syatematically.	Utilizing
CO3	Students can do this practical experiments with various approximations and assumptions which is not available do physically.	Experimental
CO4	Students design new experiments, analyze resulting data and interpret the same to provide valid conclusions.	Experimental
CO5	Students can develop their self-knowledge to critically think for the innovative ideas for the analysis of condensed matter physics and develop their own solutions to societal needs.	Higher study

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

Course Code: PHY552, Course Title: Physics Laboratory-XII(Computational Physics II)	**Practical**	**Credits: 2**

List of Experiments

1. Introduction to Linux environment and TB- LMTO code.
2. Plotting crystal structure using plotting software like VESTA.
3. Band structure plotting and analyzing for Si.
4. Plotting the total and partial density of states (DOS) andanalyzing the bonding interaction present in Si
5. Plotting and analyzing the band structure, total DOS andpartial density of states of GaAs. Comparing the electronic structure with that of Si.
6. Plotting the charge density for NaCl, Si and GaAs and analyzing bonding interaction.
7. Plotting and analyzing the band structure, total DOS andpartial density of states of TiO_2. Explain why it's a transparentconductor.
8. Plotting absorption spectra of Si and GaAs
9. Plotting COHP between C-C in diamond and between Ga-Asin GaAs and explain total energy vs Volume curve for Diamond and Lead. And calculate the Bulk modulus.

	Tasks and Assignments: 1. Execution of experiments. 2. Observation submission 3. Viva- Voce 4. Practical Examination **References:** 1. https://www.vasp.at/wiki/index.php/The_VASP_Manual 2. https://vaspkit.com/tutorials.html 3. Martin, R. (2004). Electronic Structure: Basic Theory and Practical Methods. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511805769 4. Parr, R., & Weitao, Y. (1995-01-05). Density-Functional Theory of Atoms and Molecules. : Oxford University Press. Retrieved 17 Sep. 2021, from https://oxford.universitypressscholarship.com/view/10.1093/oso/9780195092769.0 01.0001/isbn-9780195092769.

Course Outcomes

	Course Outcome	Level
CO 1	Students can understand the fundamentals of Density Functional Theory.	Fundamental
CO 2	Students can utilize the technology to do the experiments and analyze results scientifically and syatematically.	Utilizing
CO3	Students can do this practical experiments with various approximations and assumptions which is not available do physically.	Experimental
CO4	Students design new experiments, analyze resulting data and interpret the same to provide valid conclusions.	Experimental
CO5	Students can develop their self-knowledge to critically think for the innovative ideas for the analysis of condensed matter physics and develop their own solutions to societal needs.	Higher study

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	☑				
CO2	☑	☑			
CO3			☑		
CO4		☑		☑	
CO5				☑	☑

Course Code: PHY571 **Course Title: Physics Laboratory XIII (Advanced Physics)**	**Credits: 2**	**Practical**	**Hours**
	1. Growth of KDP Crystal.		3
	2. Thin film deposition using Physical Vapor Deposition Method.		3
	3. FTIR Study of binary liquids (Ethylene glycol-Ethylene system)..		3
	4. Determine the lattice constants of ceramics.		3

	Repeat/ Revisit experiments	3
	5. Growth of ADP Crystal.	3
	6. DSC – study of phase transitions in liquid crystals	3
	7. Thin film Coating by Spray Pyrolysis techniques (PVA)	3
	8. Preparation of thin film (Solid/soft matter)	3
	Repeat/ Revisit experiments	3

References:

1. B.L. Worsnop and H. T. Flint , Advanced Practical Physics, Asia Publishing House.
2. Erhan Gülmez: Advanced Physics Experiments (1999)
3. 4. Daryl W. Preston and Eric R. Dietz: The Art of Experimental Physics.
5. Class materials and the references within.

Course Outcomes

	Course Outcome	**Level**
CO 1	Working principles of the various techniques, identify the strength and limitation of each technique.	Remember
CO 2	Understand the intuitive ideas governing the functioning of various techniques, categorize and analyze the resulting data to obtain objective conclusions.	Understand
CO 3	Use the different measuring devices and meters to record data with precision and accuracy. Apply the gained knowledge on the operational details of the experiments for sample preparation.	Apply
CO4	Analyze the resulting data of the given experiment(s), and submit lab report at the end of every lab session.	Analyse
CO5	Plan and conduct experimental while employing proper note-taking methods.	Skill

General Objectives	**Specific Objectives**
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,

Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	
CO2	✓	✓	✓		
CO3	✓		✓	✓	
CO4	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	

Elective Course

Course Code: PHY0E01 **Course Title: Solar Energy and its Applications**		**Theory**	**Credits 4**
Unit -1	**Introduction** Energy scenario current, energy future, energy sources - Energy demand and availability; Conventional, Nonconventional, and Renewable energy resources; Environmental impacts of conventional energy usage.	Hours 12	
Unit -2	**Solar Collector, Thermal Technology, and Applications** Solar radiation and electromagnetic spectrum, solar radiation entering the earth system, Solar angle of incidence on tilted surface - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - testing methods - evacuated tubular collectors - concentrator collectors – compound parabolic concentrators - parabolic trough concentrators – performance of the collectors.	**12**	
Unit -3	**Solar Photovoltaic System and Applications** Basic principle of solar photovoltaic conversion, Solar cell parameters and characteristics. Block diagram of general PV conversion system and their characteristics,– Photovoltaic cell technologies - p-n junction under equilibrium and biasing, open circuit voltage and short circuit current, I-V and P-V curves, calibration and efficiency measurement – PV cell, modules, and array, - Array design, peak power point operation - Load estimation, Selection of inverters, Battery sizing, array sizing. Voltage regulation - maximum tracking - centralized and decentralized PV systems - stand alone - hybrid and grid connected system - System installation - operation and maintenances - field experience – Applications - PV market analysis and economics of PV systems.	**12**	

Unit -4	**Solar refrigeration and Air-conditioning** Potential and scope of solar cooling, Types of solar cooling systems, solar collectors and storage systems for solar refrigeration and air-conditioning, solar operation of vapor absorption cycle, temperature concentration diagram, enthalpy concentration diagram, steady flow process with binary mixtures, Energy balance for various components of vapor absorption cycle, Analysis of absorption system using concentration chart. Solar Passive Architecture - passive cooling concepts: evaporative cooling - radiative cooling.	**12**
Unit -5	**Other Applications of Solar Energy Technologies** Solar water heaters – Solar cooker – desalination - Solar Air heaters - Application of solar air heaters. Solar Drying with various driers – Heating and Drying of Agricultural products – moisture content and its measurement – solar ponds – Application of solar ponds – Solar pumping.	**12**

Tasks and Assignments:

Books recommended:

1. 1 S.P. Sukhatme, Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
2. S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition (Tata McGraw Hill, 2008)
3. G.N.Tiwari, Solar Energy: Fundamentals, design, Modeling and Applications: 2002, Narosa Publishing house
4. Fonash Solar Cell Devices : (Academic Press, New York)(1981)
5. Stooker W.F, Jones J.W. Refrigeration And Air Conditioning, Tata McGraw-Hill (2009)
6. C.P.Arora, Refrigeration And Air Conditioning Tata McGraw-Hill(2000)
7. Kreider, J.F. and Frank Kreith, Solar Energy Handbook, McGraw Hill, 1981.
8. Tiwari G.N., Tiwari A.K., Solar Distillation Practice, Anamaya Publishers, New Delhi(2008)
9. VVN Kishore, Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. (TERI Press, 2008).
10. Goswami, D.Y., Kreider, J. F. and & Francis, Principles of Solar Engineering, 2000.
11. G.D. Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi, 1999.
12. G. D. Rai , Solar Energy Utilisation, ,, Khanna Publishers,Delhi.(1996)
13. Volker Quaschning, Understanding Renewable Energy Systems, Vol. 1(2005)
14. Marcelo Godoy Simmoes Renewable Energy Systems CRC Press (2004)
15. John Twidell Renewable Energy Resources Taylor and Francis (2006)
16. Renewable Energy Sources and Their Environmental Impact Abbasi & Abbasi Prentice Hall of India (2004).

Supplementary Reading:

1. Garg H P., Prakash J., Solar Energy: Fundamentals & Applications, TataMcGraw Hill, 2000.
2. Duffie, J. A. and Beckman, W. A., Solar Engineering of Thermal Processes,John Wiley, 1991.
3. Alan L Fahrenbruch and Richard H Bube, Fundamentals of Solar Cells: PVSolar Energy Conversion, Academic Press, 1983.

	4. Larry D Partain, Solar Cells and their Applications, John Wiley and Sons,Inc, 1995. 5. Roger Messenger and Jerry Vnetre, Photovoltaic Systems Engineering,CRC Press, 2004. 6. Sodha, M.S, Bansal, N.K., Bansal, P.K., Kumar, A. and Malik, M.A.S. Solar Passive Building, Science and Design, Pergamon Press, 1986. 7. Krieder, J and Rabi, A., Heating and Cooling of Buildings: Design forEfficiency, McGraw-Hill, 1994. 8. MA Green: Solar Cells Operating Principles, Technology, and System Applications (Prentice-Hall, 1981) 9. MA Green: High Efficiency Silicon Solar 10. Cells (Trans Tech Publications)(1987) 11. SJ Fonash: Solar Cell Device Physics (Academic Press, 1982) 12. Handbook of photovoltaic science and engineering, ed. Antonio Luque andSteven Hegedus (John Wiley and Sons)(2010) 13. Anna Mani, S Rangarajan: Handbook of Solar Radiation Data for India,1980 (Allied Publishers) 14. Richard C Neville, RC Neville, Bas Van Der Hoek: Solar Energy Conversion: The Solar Cell (Elsevier Science & Technology)(1995) 15. Peter Würfel : Physics of Solar Cells: From Basic Principles to AdvancedConcepts (Wiley-VCH)(2009) 16. JF Kreider and F Kreith: Solar Heating and Cooling: Active and Passive Design (Hemisphere Publishing Corporation, 1982) 17. Low Temperature Engineering Application of Solar Energy, ed. RC Jordan(ASHRAE)(1967) 18. HP Garg and J Prakash: Solar Energy: Fundamentals and Applications (Tata McGraw Hill)(2006) 19. AB Meinel & MP Meinel: Applied Solar Energy: An Introduction (Addison) 20. Climatological and Solar data for India, Seshadri, (Sarita Prakashan), 1969. 21. Energy Technology, S. Rao and B. B. Parulekar, (Khanna Publishers), 1995. 22. Terrestrial Solar Photovoltaics, Tapan Bhattacharya, (Namsa : Publication House, New Delhi), 1998. 23. Renewable Energy Sources and Conversion Technology, N. K. Bansal, M.Kleeman and S. N. Srinivas, (Tata Energy Research Institute, New Delhi),1996. 24. Fundamentals of Solar Cells, F. A. Faherenbruch and R. H. Bube, (Academic Priess)(1983). 25. Thin Film Solar Cells, K. L. Chopra and S. R. Das, (Plenum Press), 1983. 26. Shan K. Wang, Hand Book of Air Conditioning and Refrigeration (2000) 27. Ahmadul Ameen, Refrigeration And Air Conditioning(2006)

Course Outcomes

	Course Outcome	Level
CO 1	Gain basic understanding about energy use and its environmental impact and various renewable energy technologies adopted to mitigate climate change and sustainable development.	Acquire, Understand, Apply, Skill
	Acquire knowledge about the various parameters involved in measuring the solar irradiance on earth and its variation and	Remember, Evaluate,

CO 2	various solar thermal technologies including collectors and concentrators.	Analyse, Skill
CO 3	Understand the basic aspects of photovoltaic technologies and apply it to various solar cell applications including efficiency improvement, tracking, energy storage, grid balancing etc.	Remember, Understand, Analyse, Apply
CO4	Gain knowledge about solar passive and active cooling./heating and various solar refrigeration technologies, various solar cooling technologies.	Acquire, Understand, Apply, Skill
CO5	The students will learn various applications of solar energies including solar heaters, cookers, solar ponds, solar collectors, solar desalination, solar driers and their basic working principles.	Understand, Analyse Apply,

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	✓
CO2	✓	✓			✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓			✓
CO5	✓	✓	✓	✓	✓

Course Code: PHY0E02 Course Title: Semiconductor Physics		Theory	Credits 4
Unit -1	**Semiconducting Materials and types** Origin of band gap in solids - Concept of effective mass of electron and hole – carrier concentration in an intrinsic semiconductor – electrical conductivity – band gap determination – carrier concentration in n-type and p-type semiconductors – Fermi level – Variation of Fermi level with temperature and impurity concentration – Compound semiconductors – Hall effect – Determination of Hall coefficient. Crystalline and amorphous, inorganic and organic, elemental and compound. Preparation and characteristics. Semiconductors – direct and indirect gaps – carrier statistics (intrinsic and extrinsic) – law of mass action and chemical potential of semiconductors. III - V and II – VI compound semiconductors.		Hours 12
Unit -2	**Band structure aspects** Band model of semiconductors - Effects of temperature and electric field on the band structure. Frank 'Keldysh effect. Localized states of impurities: theoretical models and experimental probes (Capacitive and spectroscopic techniques). Optical properties: allowed and forbidden . and phonon-assisted transitions and their spectral shapes. Burstein Moss effect. Excitons : free and bound excitons.		**12**
Unit -3	**Doping And Carrier Transport** Doping: Extrinsic carrier density – Heavily doped semiconductors – Modulation doping – Transport: Scattering of electrons – Phonon and ionized impurity scattering – Low field and high field transport in Si and GaAs – Transport of holes – Very high field transport: Break down phenomena – Avalanche break down (APD) – Carrier transport by diffusion - generation and recombination processes, thermionic emission process, tunneling process.		**12**
Unit -4	**Metal-semiconductor contacts:** Schottky barrier. P-N junctions: theory of carrier transport in p-n junctions. Characteristics of practical junctions and deviations from ideality. Capacitance effects: Space charge and diffusion capacitances. Impurity profiling through capacitance measurements. Tunnel diode and applications. , Physical model of p-n junction , junction capacitance and width , Breakdown phenomena , Metal-Semiconductor Junction , Rectification at metal-semiconductor Junction , Schottky-diffusion theory.		**12**
Unit -5	**Properties Of Semiconductors** Density of states for a 3 dimensional system and in sub 3 dimensional system – Holes in semiconductors, Band structures of some semiconductors. Modification of band structure by alloying and by hetero structures. Quantum well structures, Intrinsic carrier concentration, Electronic properties of defects: shallow and deep impurity levels; Photoconductivity. Role of traps and recombination. Luminescence. Light emitting diodes and laser action in p-n junction diodes.		**12**

	Tasks and Assignments: **Books recommended:** 1. Sze S M, "Physics of Semiconductor Devices", John Wiley and Sons, 2001. 2. Kevin F Brennan, "The Physics of Semiconductors", Cambridge University Press, 1999. 3. Micheal Shur, "Physics of Semiconductor Devices", Prentice Hall of India, 1999. 4. Jasprit Singh, "Semiconductor Optoelectronics Physics and Technology", McGraw Hill Co., 1998. 5. P. Y. Yu and M Cardona, Fundamentals of Semiconductors, Springer, 1992. 6. K. Seeger, Semiconductor Physics, 9th Edition, Springer, 2004. **Supplementary Reading:** 7. Michael Shur, "Physics of Semiconductor Devices", Prentice Hall of India, 1995. 8. Allen Mottorshed, "Electron Devices and Circuits", Prentice Hall Inc, 2002. 9. Jacob Millman, "Integrated Electronics", Tata McGraw Hill Publishing Co. Ltd., 2002. 10. Schwartz S, "Integrated Circuit Technology", McGraw Hill Publishing Co. Ltd., 2000. 11. Sze S M, "Semiconductor Devices – Physics and Technology", John Wiley and Sons, 2002. 12. R.A. Smith, Semiconductors, Academic Publishers, Calcutta (1989) 13. R.F. Pierret. Advanced Semiconductor Fundamentals Vol.11 Addison-Wesley (1989). 14. M. Shur, Physics of Semiconductor Devices, Prentice Hall (1990) 15. S.M. Sze, Physics of Semiconductor Devices, Wiley Eastern, 2nd Edition (1991). 16. G.C. Jain and W.B. Berry, Transpor1 Proper1ies of Solids and Energy Conversion, Tata McGraw-Hill (1972). 17. W.C. Dunlop, An Introduction to Semiconductors, Wiley (1957) 18. W. Shockley, Electrons and Holes in Semiconductors, D. Van Nostrand (1950). 19. "Physics of submicron devices" by D.K. Ferry and R.O. Grondin, Plenum (New York, 1992). 20. "Semiconducctor Physics Electronics" by Sheng Li, (Plenum, New York, (1993). 21. "Physics of optoelectronic devices" by S.l. Chang (1995). 22. "Fundamental of semiconductor theory and device physics" by Shyh Wang (1989) 23. "Semiconductor physics: Pioneering papers" by S.M. Sze (John Wiley, New York, 1991)

Course Outcomes

	Course Outcome	Level
CO 1	To get knowledge about various aspects of semiconducting materials and their electrical conductivity with temperature and doping.	Acquire, Understand, Remember

CO 2	Understand the concept of electronic band structure and its changes with impurities, temperature, electric field etc. and their role on optical properties.	Understand, Evaluate, Analyse, Skill
CO 3	Understand the role of doping on the transport properties including the scattering of ions, electron-phonon etc. and also the effect of electric field, temperature break down, thermionic emission, tunneling effects on charge transport.	Understand, Analyse, Apply
CO4	Understand the electrical transport across interface between metal-semiconductor, semiconductor P-N junction etc. and also the capacitance effects at the junctions.	Understand, Analyse Apply
CO5	Gain knowledge about the changes in opto-electronic properties by alloying, quantum structures, defect levels and heterostructuresin semiconducting materials.	Understand, Apply, Skill

General Objectives	**Specific Objectives**
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓		✓	✓
CO2	✓	✓			✓
CO3	✓	✓	✓	✓	✓

CO4	✓	✓			✓
CO5	✓	✓	✓	✓	✓

Course Code: PHY0E03 **Course Title: Properties of Materials**	**Theory**	**Credits 4**

Unit -1	**Mechanical properties** Factors affecting mechanical properties - mechanical tests - tensile, hardness, impact, creep and fatigue - Plastic deformation by slip - shear strength - work hardening and recovery - fracture - Griffith's theory - slip and twinning - creep resistant materials - diffusion – Fick's law.	Hours 12
Unit -2	**Optical Properties:** Electrons in electromagnetic field, optical absorption in insulators, semiconductors and metals – band to band absorption – Inter band and intra band transitions - charge injection and radiative recombination – The continuity equation: Diffusion length, excitonic effects and modulation of optical properties. Luminescence – photoconductivity, photoelectricity, LED and liquid crystal displays. Non-linear optics - wave propagation in Non-linear dielectrics - Electrooptic and Nonlinear optic co-efficients -The nonlinear susceptibility – Opticab l second Harmonic generation.	**12**
Unit -3	**Thermal and Thermoelectric Properties**: Thermal conduction - Thermal conductivity, Flow of heat through compound media. Determination of thermal conductivity of conductors by Forbe's method, Lattice vibrations, harmonic approximation, dispersion relations and normal modes, quantization of lattice vibrations and phonons. thermal expansion and need for anharmonicity. Transport properties of solids. Boltzmann transport equation. Wiedemann-Franz law. Lattice vibrations, phonons, adiabatic & harmonic approximations, lattice heat capacity, Einstein and Debye models. Seebeck, Peltier, and Thomson effects - laws of thermoelectricity - thermoelectric curve - neutral and inversion temperature, thermoelectric power .	**12**
Unit -4	**Magnetic Properties:** Classification - dia, para, ferro, antiferro and ferrimagnetism – Langevin and Weiss theories - Heisenberg's theory of exchange interaction - magnetic aniostrophy - magnetic domains - Weiss molecular field theory – Classical and quantum theory of paramagnetism, Curie's law, spontaneous magnetization and domain structure, spontaneous magnetization and its temperaturedependence. Curie-Weiss law, explanation of hysteresis. - hard and soft magnetic materials - ferrite structure and uses - - magnetoresistance - GMR materials - dilute magnetic semiconductormaterials. Spin waves and magnons.	**12**

Unit -5	**Dielectric and Ferroelectric Properties:** Dielectric constant and polarizability - Static dielectric constant, electronic, ionic and orientation polarizations - Internal or local fields in dielectrics Clausius- Mossatti equation - complex dielectric constant - determination of dipole moment for polar substances - dielectric losses - frequency dependence of electronic, ionic, orientation polarisabilities - dielectric loss. General properties of ferroelectrics- Curie Weiss behavior - classification of ferro electric materials - dipole theory of ferro electricity - ferro electric domains - applications - piezoelectric and pyroelectric materials and applications.., Ferroelectric materials- Pervoskite crystal structure (eg.$BaTiO_3$ and PZT).	**12**
	Tasks and Assignments: **Books recommended:** 1. V. Raghavan, "Materials Science and Engineering: A First Course", Prentice Hall, 2006. 2. S. O. Pillai," Solid state physics", New age International Pvt Ltd, 6th edition, 2005 3. Wahab, M. A.," Solid State Physics", Narosa Publishing, 2nd Edition, 2005 4. C. Kittel, "Introduction to Solid State Physics" Wiley Eastern Ltd., 2005. 5. N.W. Ashcroft and N.D. Mermin Solid state physics, India edition IE, Thomsom books, Reprint, 2007. 6. johnSingleton: Band theory and Electronic properties of Solids (OxfordUniversity Press; Oxford Master Series in Condensed Matter Physics). 7. Electricity and Magnetism: Brijlal & Subrahmanyam Ratan PrakashanMandir Publishers -1995. 8. Harald Ibach and Hans Lüth " An Introduction to principles of MaterialsScience", Springer, 2003. 9. James D. Patterson, Bernard C. Bailey," Solid State Physics: Introductionto the theory", Springer-Verlag, edition 1, 2005 10. Jasprit Singh, "Semiconductor Optoelectronics Physics and Technology",McGraw Hill Co., 1998 11. H.P.Myers, Introductory Solid State Physics, 2nd edition, Viva Books Pvt.Ltd (1998) 12. M.Ali Omar, Elementary Solid State Physics, revised printing PearsonEducation (2000) 13. M.S. Rogalski and S.B. Palmer, Solid Statae Physics, Gordon BreachScience Publishers (2000) 14. Y.K. Lim, Problems and solutions on Solid State Physics, Sarat BookPublishers (2002) 15. Fundamentals of Electricity and Magnetism: R.G.Mendiratta andB.K.Sawhney East - West Press(1976) 16. E. Lines and A.M.Glass, Principles and applications of ferroelectricsmaterials, Clarendon press, Oxford ,1979.	

	17. K.V.Keer, Principles of solid state physics, Wiley - Eastern, 1993. **Supplementary Reading:** 1. W. D. Callister, "Materials Science and Engineering: An Introduction",John Wiley & Sons, 2007. 2. Michael Shur, "Physics of Semiconductor Devices", Prentice Hall ofIndia, 1995. 3. S. Blundell, Magnetism in condensed matter, Oxford university press,2001. 4. A. Aharoni, Introduction to the theory of ferromagnetism, Oxforduniversity press, 2001. 5. Y. D. Jiles, Introduction to magnetism and magnetic materials, Chapmeanand Hall. (2nd edition). 6. L. L. Hench, J. K. West, Principles of electronic ceramics, John Wiley andsons,1995. 7. D.R.Tilley and J.Tilley, Superfludity and superconductivity, 3rd Edition,Hilger,1990. 8. M. Marder, Condensed Matter Physics 9. A.J.Dekkar, Electrical Engineering Materials, Prentice Hall, New Delhi,1996 10. A.J. Dekker, "Solid State Physics”, Macmillan & Co., 2000

Course Outcomes

	Course Outcome	**Level**
CO 1	Gain fundamental understanding about stress-strain relation and the role of micro/nano structures on mechanical properties.	Acquire, Understand, Apply, Skill
CO 2	Develop fundamental knowledge about the interaction of light with matter and explain optical properties of insulators, semiconductors and metals through interband and intraband transitions. Understand electro-optic and non-linear optical properties microscopically and gain knowledge about various optical transitions such as photoconductivity, luminescence, excitonic effects, photoelectricity etc.	Remember, Evaluate, Analyse, Skill
CO 3	Acquire knowledge about the origin of thermal properties in solids and the role of phonon on transport properties. Get brief introduction about the thermoelectric properties of solids.	Remember, Understand, Analyse, Apply
CO4	Gain knowledge about the origin of various magnetic ordering and the theory to explain the magnetic properties and its applications.	Acquire, Understand, Apply, Skill
CO5	Understand the origin of dielectric polarization and the role of symmetry on spontaneous electric polarization. Classify the piezoelectric, pyroelectric and ferroelectric materials and gain knowledge about the relevant theoretical developments.	Understand, Analyse Apply,

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	✓
CO2	✓	✓			✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓			✓
CO5	✓	✓	✓	✓	✓

Course Code: PHY0E04 **Course Title: -Physics of Materials Synthesis**		**Credits: 4**	**Theory**	**Hours**
Unit -1	**Bulk Materials Synthesis Techniques:** Powders synthesis method; mechanical methods, hydrothermal synthesis of ceramic oxide powders, chemical methods.			08

Unit -2	**Crystal Growth:**The crystalline state – classification of crystal growth methods Nucleation – homogeneous and heterogeneous nucleation Melt Growth techniques - Bridgman – Stockbarger method – Czochralski pulling method – Kyropolous method – Non-conservative processes: Zone-refining – Vertical and horizontal float zone methods – Skull melting method – Vernueil flame fusion method**, Solution Growth Techniques -** Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods – Crystal growth in Gel media – Growth from high temperature solutions - Flux growth principles of flux method –Growth by slow evaporation and slow cooling methods – Hydrothermal growth method.**, Vapour Growth Techniques –** Vapour phase crystallization in a closed system – Gas flow crystallization - growth by chemical vapor transport reaction.	14
Unit -3	**Thin Film Synthesis Techniques:** Physical vapor deposition, Pulsed LASER Deposition, Sol-Gel, Molecular Beam Epitaxy, Chemical vapor deposition (CVD), Electroplating and anodisation. Plasma enhanced chemical vapor deposition (PECVD) - Sputter technologies - DC and RF sputtering - Evaporation: Resistive heating, electron beam gun - Metal Organic Chemical Vapor Deposition (MOCVD)-Combustion Chemical Vapor Deposition(CCVD) - Atomic Layer Deposition(ALD) - Liquid phase epitaxy (LPE) - Molecular Beam Epitaxy. Sol-gel synthesis (MBE) – different types of coatings -Spin coating.	12
Unit -4	**Synthesis of Nanomaterials**: Basic approaches- top down and bottom up approaches- various methods for producing nanomaterials. Solid State (Mechanical methods): Mechanical Alloying (MA) and Mechanical Milling (MM)- Severe Plastic deformation. Chemical synthesis: sol-gel method and co-precipitation techniques, Chemical Vapour Deposition (CVD). Physical methods: Condensation, Physical Vapour Deposition (PVD) - Thermal Spray Processing. Examples of materials (metals, alloys, ceramics) produced by each class-comparison of physical, chemical and mechanical methods.	12
Unit -5	**Synthesis of Nanoparticles**: Introduction – hydrolysis-oxidation-thermolysis - metathesis-solvothermel methods.sonochemistry; nanometals-powers of metallic nano particles-metallic colloids &alloys -polymer metal composites-metallic oxides-rare earth oxides-mesoporous materials-mixed oxides. sono electro chemistry-nanocrystalline materials. micro wave heating-micro wave synthesis of nano metallic particles. quantum-dots from MBE and CVD, wet chemical methods, reverse micelles, electro-deposition, pyrolytic synthesis, self-assembly strategies.	14
	Tasks and Assignments: 1. **References:** Ichiro Sunagawa, "Crystals: Growth, Morphology and Perfection" Cambridge University Press, Cambridge, 2005. 2. Ramasamy, P. & Santhanaraghavan. P. Crystal growth processes and methods, KRU Publications, 2000. 3. Mullin J W, "Crystallization" Elsevier Butterworth-Heinemann, London, 2004. 4. Brice J C, "Crystal growth processes", John Wiley and Sons, New York, 1986.	

	5. Milton Ohring, material science of thin film deposition and structure, academic press, John Wiley New york, 2006. 6. Maissel L I, Glang R Hand book thin film technology Mc Graw Hill 2 nd edition. 7. Milton Ohring, The Materials Science of Thin Films, Academic Press, 2001. 8. Donald L. Smith, Thin-Film Deposition: Principles and Practice, McGraw Hill, 1995. 9. K.L. Chopra and I.J. Kaur, Thin Film Device Applications, Plenum Press, London, 1983. 10. Rao C N R, Muller A and Cheetham A K, "The Chemistry of Nano materials: Synthesis, Properties and Applications", Vol. 1 & 2, Wiley-VCH, 2003 11. G. Cao, "Nanostructures & Nanomaterials: Synthesis, Properties &Applications" Imperial College Press, 2004. 12. W.T.S. Huck, "Nanoscale Assembly: Chemical Techniques (Nanostructure Science and Technology)" **Suggested Reading:** 1. L.I. Maissel and R. Glang (Eds.), Handbook of Thin film Technology, McGraw- Hill, 1970. 2. 1. M. Ohring,*The materials Science of Thin films*, Amazon, 2001. 3. M. N. Rahaman, *Ceramic Processing*, CRC Press, Taylor & Francis Group, FL, 2007. 4. Pradeep T, " Nano : The essentials", Tata Mc Graw Hill Publishing Company Limited, New Delhi, 2007 5. Parag Diwan and Ashish Bharadwaj, "Nano Structured Materials", Pentagon Press, 2006 6. M. J. Jackson, "Micro fabrication and Nanomanufacturing", CRC Press, 2005. 7. P.Rai-Choudhury, "Handbook of Micro lithography, Micro machining, and Micro fabrication", Vol. 2, SPIE Press, 1997. 8. M. Madou, "Fundamentals of Microfabrication," CRC Press, 1997. 9. G.Timp, "Nanotechnology", AIP press, Springer-Verlag, New York, 1999. 10. Milton Ohring, material science of thin film deposition and structure, academic press, John Wiley New york, 2006. 11. Maissel L I, Glang R Hand book thin film technology Mc Graw Hill 2 nd edition. 12. R. Sahu, *Physics of solid, nuclei and particle,* Narosa publishing house, 2006. 13. C. C Julian, *Introduction of electron Scanning Tunneling Microscopy,* Coulombia university press, 2006 14.. Buckley, H.E., Crystal growth, John Wiely and sons, New York,1981. 15. Elwell,D & Scheel, H.J., Crystal growth from high temperature solution, Academic Press, New York,1995. 16. Laudise, R.A. The growth of single crystals, Prentice Hall, Englewood,1970.

Course Outcomes

	Course Outcome	Level
CO 1	Mechanisms and key features of current and emerging processing techniques employed to fabricate of single crystals, bulk and nano structured materials.	Remember

CO 2	Understand and explain the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials.	Understand
CO 3	Choose appropriate synthesis technique to synthesize 3 dimensional, 2 dimensional, 1 dimensional and 0 dimensional materials of desired size, shape and material properties.	Apply
CO4	Analyze and correlate physical and chemical properties of materials with their processing technique.	Analyse
CO5	Demonstrate the ability to develop case studies of various materials with a focus on fundamentals, fabrication, characterization, and applications.	Skill

General Objectives	**Specific Objectives**
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			
CO2	✓	✓	✓		
CO3	✓	✓	✓	✓	
CO4	✓	✓		✓	
CO5	✓	✓	✓	✓	

Course Code: PHY E015 Course Title: NONLINEAR DYNAMICS		Theory	Credits 4
Unit -1	Linear and Nonlinear systems - Mathematical models examples – Mathematical Implications of Nonlinearity: superposition principle and its validity - Examples and problems - linear andnonlinear oscillators – Frequency response curve - Resonance and Hysteresis - Examples and problems - Autonomous and nonautonomous systems - Phase plane trajectories - stability, attractors and repellers - limit cycle - Examples and problems - Phase space - classification of equilibrium points and Eigen values - stability of fixed points - Examples and problems		Hours* 12
Unit -2	Bifurcation - the logistic map – Feigenbaum ratio - period doubling phenomenon- Bifurcation diagram - onset of chaos- other routes to chaos -Lorentz systems - Sensitive dependence on initialcondition - controlling of chaos -bifurcation scenario in Duffing oscillator- Examples and problems		**12**
Unit -3	Linear and nonlinear dispersive wave propagation - Fourier transformation and solution of initial value problem - wave packet and dispersion - Nonlinear dispersive system - Korteweg-de Vries equation and the solitary waves and Cnoidal waves - Scott Russel's phenomenon and Korteweg- de Vries equation - Fermi-Pasta-Ulam lattice problem - FPU recurrence phenomenon – discrete Korteweg-de Vries equations (KdV and mKdV) - numerical experiment of Zabusky and Kruskal- birth of soliton.		**12**
Unit -4	Integrability and methods to solve soliton equations - The notion of integrability – Nonlinear perturbation theory - multiple scale perturbation method - soliton solutions of perturbed nonlinear Schrödinger equation - Hirota's direct method and 'N' soliton solutions – Painleve's analysis; Leading order – Resonance – Arbitary Analysis and its application to Korteweg-de Vries equation, nonlinear Schrödinger equation- Lax pair for Korteweg-de Vries equation.		**12**
Unit -5	Applications of Nonlinear dynamics - soliton applications in all optical communication - Energy transfer soliton in polypetides protein and Davydov Soliton DNA - Function of soliton in cytoskeleton neuronal microtubules - Ion-acoustic solitons in plasma: an application to Saturn's magnetosphere - Pulse solitons in blood circulatory systems.		**12**

Course Outcomes

	Course Outcome	Level
CO 1	To be able to understand basic concepts of dynamical system and analyse the mathematical Implications of Nonlinearity (e.g. linear and nonlinear oscillators – Frequency response curve). To be able to finding fixed points and determine their stability (e.g. Phase space, classification of equilibrium points and Eigen values)	
CO 2	To be able to analyse changes (i.e. bifurcations) to dynamical systems as system parameters are varied including the logistic map, period doubling phenomenon Feigenbaum ratio, Bifurcation diagram with appropriate examples.	

CO 3	To understand the properties of linear and nonlinear dispersive waves and localization with various phenomenon such as Korteweg-de Vries equation and the solitary waves and Cnoidal waves, Scott Russel's phenomenon and Korteweg- de Vries equation, Fermi-Pasta-Ulam lattice problem, FPU recurrence phenomenon, discrete Korteweg-de Vries equations (KdV and mKdV), etc..	
CO4	To analyse the integrability and concept of nonlinear perturbation theory and applying various mathematical methods (multiple scale perturbation method, Hirota's direct method and 'N' soliton solutions) to solve the nonlinear equations for soliton solution. To apply the analysis of Painleve's analysis, Leading order Resonance and Arbitary Analysis to the nonlinear equations	
CO5	To study the applications of solitons in different biological systems as Energy transfer soliton in polypetides protein, Davydov Soliton DNA, soliton functioning in cytoskeleton neuronal microtubules and Pulse solitons in blood circulatory systems and the applications to the several field like optical communication, Ion-acoustic solitons in plasma and an application to Saturn's magnetosphere.	

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓

Course Code: PHY0E23 **Course Title: Advanced Electromagnetic Theory**	**Theory**	**Credits 4**
Unit -1	**POLARIZATION IN MATTER** Electric fields in matter – induced dipoles and electric susceptibility, forces and torques on dipoles in non-uniform fields, Polarization of a medium, field due to polarized object – concept of bound and surface charges, field of an uniformly polarized sphere, electric displacement – Gauss's in the presence of dielectrics, boundary conditions, linear dielectrics, dielectric constant, energy stored in dielectric systems, forces on dielectrics.	Hours* 12
Unit -2	**MAGNETIZATION IN MATTER** Magnetic fields in matter – magnetic dipoles – forces and torques on magnetic dipoles, induced orbital dipole moment in atoms – origin of diamagnetism, field due to magnetized object – concept of bound and surface currents, field of an uniformly magnetized sphere, Ampere's law in magnetized materials, boundary conditions, linear magnetic media – susceptibility and permeability, energy of a magnetic dipole in magnetic field, interaction energy of two magnetic dipoles	**12**
Unit -3	**POTENTIAL FORMULATIONS OF ELECTRODYNAMICS** Scalar and vector potentials in electrodynamics, Gauge transformations, Lorentz gauge, Coulomb gauge, Retarded potentials of continuous charge and current distributions, Jefimenko's	**12**

	equations, Retarded potential and fields of an current carrying wire, Retarded potential of a point charge in motion – Lienard Wiechert Potentials, Retarded potentials and fields of a moving point charge – uniform linear and circular motion, fields of a line charge in uniform motion.	
Unit -4	**RADIATION** Electric dipole radiation – power radiated by dipole oscillations, Magnetic dipole radiation – Intensity of radiation, Radiation from an arbitrary source of charges and currents, fields of quadrupole radiation, power radiated by an accelerated point charge – Larmor formula, Radiation reaction and its physical explanation, Abraham-Lorentz formula, Radiation damping	**12**
Unit -5	**RELATIVISTIC ELECTRODYNAMICS** Magnetism – Relativistic viewpoint, Transformation of electric and magnetic fields – Lorentz transformation, electric and magnetic fields of a point charge in uniform motion – Gauss's law for charges in motion, relativistic invariance of field quantities, transformations of an electromagnetic plane wave, Electro-magnetic field tensor, electrodynamics in tensor notation, Lorentz-Force law in relativity, Relativistic potentials.	**12**
	Tasks and Assignments: **References:** 1. David J. Griffiths, Introduction to Electrodynamics, Pearson Publisher, 4th Edition, 2012. 2. Tai L. Chow, Introduction to Electromagnetic Theory, Jones & Bartlett Publishers, First Edition, 2012. 3. J A Stratton, Electromagnetic Theory, Read Books Publisher, First Edition, 2010. 4. J R Reitz, Foundations of Electromagnetic Theory, Narosa Publisher, Third Edition, 1997. 5. J D Jackson, Classical Electrodynamics, John Wiley, Third Edition, 1998.	

Course Outcomes

	Course Outcome	Level
CO 1	Explain basic processes of electric and magnetic fields in matter by defining polarization and magnetization.	Remember
CO 2	The concept of retarded potentials and radiation from accelerated charges.	Understand
CO 3	Apply the concept of retarded potentials to explain radiation from oscillating electric and magnetic dipoles.	Apply
CO4	Analyze the relativistic effects in electrodynamics to solve advanced problems in physics.	Analyze

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new Context	Employ, Illustrate, Use, Solve

Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓			✓	✓
CO2	✓			✓	✓
CO3	✓			✓	✓
CO4	✓			✓	✓

Course Code: PHY0E29 **Course Title: Nano materials And Nano technology**		**Theory**	**Credits 4**
Unit -1	**Introduction** Introduction to nanotechnology, physics of low-dimensional materials, quantum effects, 1D, 2D and 3D confinement, Density of states, Excitons, Coulomb blockade, Zero-, One-, Two- and Three-dimensional structure, Size control of metal nanoparticles and their properties: optical, electronic, magnetic properties; surface plasmon resonance, change of bandgap; Application: catalysis, electronic devices		Hours 12
Unit -2	**Nanofabrication** Importance of size distribution control, size measurement and size selection, assembling and self-organization of nanostructures, Nanofabrication: patterning of soft materials by self-organisation and other techniques, chemical self-assembly, artificial multilayers, cluster fabrication, Langmuir-Blodget growth, Nanolithography, Scanning probe lithography, Micro contact printing.		**12**
Unit -3	**Nanoelectronics and devices** Advantages of nano electrical and electronic devices, micro and nano-electromechanical systems – sensors, actuators, optical switches, bio-MEMS diodes and nano-wire transistors - data memory lighting and displays, filters (IR blocking) – quantum optical devices – batteries - fuel cells and photo-voltaic cells – electric double layer capacitors – lead-free solder – nanoparticle coatings for electrical products		**12**
Unit -4	**Nanocatalysts and Nanoporous materials** Nanocatalyts, smart materials, heterogenous nanostructures and composites, nanostructures for molecular recognition (quantum dots, nanorods, nanotubes) – molecular encapsulation and its applications – nanoporous zeolites – self-assembled nanoreactors - organic electroluminescent displays		**12**

Unit -5	**Nanotechnology for Nanomedince** Drug deliveries, drug delivery system, nanoparticle in drug delivery-available applications, nanotechnology future application understanding for treatment. Manufacture of nanoparticles, nanopowder and nanocrystals, targeting ligands applications of nanoparticle in drug delivery, cancer treatment, tissue regeneration, growth and repair, impact of drug discovery and development.	**12**
	Tasks and Assignments:	

Books recommended:

1. Nanolithography and patterning techniques in microelectronics, David G. Bucknall, Wood head publishing 2005
2. Transport in Nanostructures, D.K. Ferry and S.M. Goodmick, Cambridge university press 1997.
3. Optical properties of solids, F. Wooten, Academic press 1972
4. Micro and Nanofabrication, Zheng Cui, Springer 2005
5. Nanostructured materials, Jackie Y. Ying, Academic press 2001
6. Nanotechnology and nanoelectronics, W.R, Fahrner, Springer 2005
7. Hand book of Nanoscience, Engineering, and Technology, William A. Goddard, CRC press 2003.
8. Nanoelectronics and Information Technology, Rainer Waser, Wiley-VCH 2003.
9. The MEMS Handbook Frank Kreith, CRC press 2002.
10. Charles P. Poole, Jr., Frank J. Owens, "Introduction to nano technology",Wiley, 2003.
11. Gunter Schmid, "Nanoparticles: From Theory to Applications", Wiley-VCH Verlag GmbH & Co., 2004.

Supplementary Reading:

1. Pradeep T "Nano: The Essentials", Mc Graw Hill Publishing Co. Ltd.,2007
2. Mick Wilson et al, "Nanotechnology", Overseas Press (India) Pvt.Ltd., 2005.
3. Nanoengineering of structural, functional and smart materials, Mark J. Schulz, Taylor & Francis 2006.
4. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005

Course Outcomes

	Course Outcome	**Level**
CO 1	To get brief introduction about the nanomaterials and nanotechnology. Also understand the size and shape dependent on the physical properties of materials at nanoscale.	Acquire, Understand,Apply, Skill
CO 2	Gain knowledge about the importance of size distribution, size selectivity, self-assembly on properties of nanoscale materials. Understand various nanofabrication techniques used to synthesis nanomaterials.	Remember, Evaluate, Analyse, Skill
CO 3	Analyse the advantages of using nanotechnology for various electronic applications.	Remember, Understand, Analyse, Apply

CO 4	Understand molecular recognition, molecular encapsulation, nanocomposites, nanoreactors, nanoporous materials for catalysis and smart applications.	Acquire, Understand,Apply, Skill
CO 5	Gain knowledge about nanomedicine, targeted drug delivery, diagnosis and treatment. Understand bio-inspired, bio-mimicking and bio-compatible nano-materials.	Understand, Analyse, Apply.

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in yourown words, Differentiate, Cite example, Relate,Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement onthe value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	✓
CO2	✓	✓			✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓			✓
CO5	✓	✓	✓	✓	✓

Course Code: PHY0E30 **Course Title:** Physics of Magnetism and Spintronics		**Theory**	**Credits 4**
Unit -1	**Fundamental of Magnetism** Origin of permanent magnetic dipoles; Quantum theory of the magnetic moment; Hund's rules. Classical and quantum aspects of diamagnetism; paramagnetism; Curie law; formula of Van Vleck; Crystal field: d-f- metals, magnetic anisotropy; adiabatic demagnetization; Ferromagnetism; Weiss theory; domains; Bloch wall; Hysteresis;		Hours* 12
Unit -2	**Magnetic Interactions and Relaxation** Exchange interaction, super-exchange, double exchange. Band magnetism. Collective excitation; Long-range order: Mean field theory: the theory of Weiss (Neel). Molecular field. Order parameter. Ferro-, antiferro-, iron-magnetism, other types of order. Spin glass, Magnetic domains. Hard & soft materials. Domain Theory; Exchange bias. Spin –latttice relaxation; spin-spin relaxation		**12**
Unit -3	**Nano-magnetism**. Single-domain particle; Super-paramagnetism; Nanoparticles & molecular magnets.Stoner Wohlfarth model; Landau-Lifschitz-Gilbert Model; Neel-Brown model. Nanoscale magnetisam in small particles; thin films; wires; needles and bulk nanostructures		**12**
Unit -4	**Spintronics**: Spin polarized currents; magnons; Spin-orbit interaction; Spin relaxation; Spin dependent Scattering and Transport; Spin dependent tunneling and Transport; Spin valve;Giant Magneto Resistance; Magnetic Random Access Memory; spin torque; Spin transfer oscillators; spin transistors		**12**
Unit -5	**Molecular magnetism:** High-spin, low spin molecules; quantum theory of molecular magnetisam: tunneling of magnetization; other functionalities of molecular nanomagnets: magneto caloric effect;		**12**

Course Outcomes

	Course Outcome	**Level**
CO 1	Identify different kinds of magnetism in solids.	Remember
CO 2	Understanding fundamentals of magnetism; magnetic anisotropy, magnetic domain kinetics; magnetic hysteresis.	Understand
CO 3	Description of long-range magnetic order and of magnetic phenomena at the nanoscale and at molecular and atomic level; Various spin dependent transport phenomena; magnetoresistance effect; Spin-torque transfer phenomenon	Understand
CO4	Compare the materials with regards to their magnetic and transport properties and analyse their relevance in relation to technological applications;	Analyse
CO5	Generalize device concepts, theories, and materials requirements for spintronic devices	Skill

General Objectives	**Specific Objectives**
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate

Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓			
CO2	✓	✓			
CO3	✓	✓			✓
CO4	✓	✓		✓	
CO5	✓	✓			✓

Course Code: PHYE032 Course Title: ASTROPHYSICS		**Theory**	**Credits 4**
Unit -1	Astronomical scales (Distance,Mass, Time), Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scales, Distance Modulus, Measurement of astronomical quantities- Distance, Stellar Radii, Masses of stars from binary orbits, Stellar temperature, Color index of stars. Spectral types and their temperature dependence, Hertzsprung-Russell (HR) diagram.	Hours* 12	
Unit -2	Celestial Sphere, Geometry of a sphere, Astronomical coordinate systems - Horizon system, Equatorial system, Coordinate transformation between 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.	**12**	
Unit -3	Observing through the atmosphere- Atmospheric Windows, optical telescopes, Radio telescopes, telescope mountings, Magnification, Light gathering power, resolving power and diffraction limit, Detection limit of telescope. Derivation of Virial theorem, Basic equations of stellar structure, simple stellar models- Polytropic model, derivation of the Lane-Emden equation, analytic solution of Lane-Emden equation	**12**	
Unit -4	Morphological classification of the Galaxies. Basic structure and properties of the Milky way, Nature of rotation of the Milky Way-differential rotation of the Galaxy and Oort constants, rotation curve of the galaxy and the dark matter	**12**	

Unit -5	Cosmological observations, The cosmological principle, Homogeneous and isotropic universe, Friedmann model, Evolution of our universe	12
	Tasks and Assignments: **References:** Theoretical Astrophysics, Vol 1- T. Padmanabhan Fundamental Astronomy, H. Karttunen et. al. Suggested Readings: 1. An Invitation to astrophysics T. Padmanabhan 2. Galactic dynamics- J. Binney and S. Tremaine	

Course Outcomes

	Course Outcome	Level
CO 1	Get the idea of scales (length, mass and time) and order of magnitudes involved in astrophysics, quantities used for astronomical measurements.	Remember, Understand, skill
CO 2	Get the idea of coordinate systems used in astronomical observations,mounting of telescopes in different coordinate systems	Understand, Apply, skill
CO 3	Give the idea of challenges involved in astronomical observations.Give the theoretical understanding of stellar evolution	Understand, Analyze, Apply
CO4	Idea of classification of galaxies, rotation curve of galaxies and observation leading to the idea of dark matter. Emphasize the complementarity of theory and observation.	Understand, Analyze
CO5	Emphasize the importance of scales to give the idea of cosmological principles, observations leading to the current understanding of our universe,	Understand, Apply, Analyse

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish

Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	
CO5	✓	✓	✓	✓	

Couse code: PHY0E33 **Course title: Plasma Physics**	**Theory**	**Credits 4**
Unit -1	**Basics of plasmas:** Plasma as the fourth state of matter, macroscopic neutrality, Debye shielding, plasma frequency, the occurrence of plasma in nature, collisions, dc conductivity, ac conductivity, diffusion,production of plasma: dc discharge, rf discharge, using particle beam, laser produced plasma, overview of some plasma devices.	Hours **12**
Unit -2	**Waves in plasmas:** Plasma oscillations, Fluid description of plasma: equation of continuity, the fluid equation of motion, motion of charged particle in uniform electromagnetic fields, charged particle motion in time varying electromagnetic fields, Electron plasma waves, Ion acoustic wave, Electromagnetic waves in unmagnetizedplasma.	**15**
Unit -3	**Atomic processes in plasma:** Ionization processes, recombination processes; Plasma equilibrium model: thermal equilibrium, local thermal equilibrium, corona equilibrium, collisional radiative equilibrium; Radiation from plasma: blackbody radiation, bremsstrahlung radiation, recombination radiation, line radiation, cyclotron radiation.	**6**
Unit -4	**Laser plasma interaction:** Ponderomotive energy, Keldysh parameter, multi-photon ionization, optical field ionization, high harmonic generation, Laser absorption processes: inverse bremsstrahlung, resonance absorption, Landau damping; Parametric decay processes, two plasmon decay, stimulated Brillouin scattering, stimulated Raman scattering.	**15**
Unit -5	**Applications:** Laser induced breakdown spectroscopy, Laser-plasma based ion acceleration, Laser wakefield acceleration, Inertial confinement	**12**

	fusion, Magnetic confinement fusion, Laser-plasma based x-ray laser.	
	Reference books: 1. *Principles of Plasma Physics*, Nicholas A. Krall and Alvin W. Trivelpiece (McGraw-Hill Book Company). 2. *Introduction to Plasma Physics and Controlled Fusion*, Francis F. Chen (Springer). 3. *The Physics of laser-plasma interaction*, W. L. Kruer (Addison-Wesley Publishing Co.). 4. *Short pulse laser interaction with matter- an introduction*, Paul Gibbon (Imperial College Press). 5. *Fundamentals of Plasma Physics*, J. A. Bittencourt (Springer). 6. *The Physics of Plasmas*, T. J. M. Boyd and J. J. Sanderson (Cambridge University Press).	

12.2 Course Outcomes

	Course Outcome	Level
CO 1	It provides a basic introduction to the subject, intended to give the students an overall view of various properties of plasma and the techniques to produce it.	Understand
CO 2	Developing the fundamental equations necessary for an elementary description of plasm and learning its response to external electric and magnetic fields.	Understand Skill Apply
CO 3	Learning various processes occurring in the plasma at the atomic level.	Understand
CO4	Understanding the fundamental physicsof high-power laser interaction with plasmas which help in understanding various applications related to this topic.	Apply Skill
CO5	Learning about some of the important research areas where the physics learnt in this course is applied.	Apply Skill

12.3 Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1			✓		✓
CO2	✓			✓	✓
CO3			✓		✓
CO4	✓	✓	✓	✓	✓
CO5	✓	✓		✓	✓

Course Code: PHY0E34 Course Title: Introduction to classical field theory		Theory	Credits 4
Unit -1	Recap of the Principle of relativity: concept of interval, proper time, Lorentz transformation, transformation of velocities, four vectors, and covariant notation. Relativistic mechanics: The principle of least action, Energy and momentum, transformation of distribution functions, decay of particles, invariant cross-section	15 Hours	
Unit -2	Concept of natural units, idea of fields, Discrete and continuous mechanical systems, Classical scalar field (real and complex): Action, Lagrangian, Hamiltonian, Equation of motion, free and interacting field theories, stress-energy tensor.	15 Hours	
Unit -3	Charges in electromagnetic fields: Four potential, action, Lagrangian, Hamiltonian. Equation of motion of a charge in a field, gauge invariance, electromagnetic field tensor, Lorentz transformation of the fields, invariants of the field. Action of the electromagnetic field, current vector, continuity equation, Maxwell's equations, Poynting vector, energy momentum tensor	15 Hours	
Unit -4	Particles in a gravitational field: Concept of metric, distances and time intervals, covariant differentiation, Christoffel connection and its relation with the metric tensor, equation of motion of a particle in gravitational field, gravitational redshift, equation of electrodynamics in presence of gravitation, Action function of gravitational field, energy momentum tensor, Einstein's equation.	15 Hours	
	References: 1. Classical theory of field, Course of theoretical physics Vol 2 L.D.Landau and E.M. Lifshitz.		

Course Outcomes

	Course Outcome	Level
CO 1	Concepts of relativity, transformations, invariants	Understand ,Remember
CO 2	Idea of fields, linear and non-linear equation of motion, free and interacting theories	Understand
CO 3	Idea of vector fields, energy momentum tensor for vector field and behaviour charge particles in electromagnetic field	Understand , Apply
CO4	Tensor calculus, Background of general relativity, Einstein's Equation	Understand , Apply

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

Course Code: PHY S01 **Course Title: Physics of Art**	**Theory**	**Credits 4**
Unit -1	Introduction to Physics – What is science? What is Physics? Quantification of natural phenomenon, length, mass and time scales of humans and that of the Universe, Role of mathematics in understanding qualitative phenomenon and its limitations	Hours* **12**
Unit -2	Introduction to arts, its role in society, historical role of arts in the progression of science, influence of science on arts – with special reference to photography/motion picture and paintings,	**12**
Unit -3	Physics of Music : Introduction to music and its forms; Physics of pitch, loudness and timbre; melody, symphony and harmony – a basic understanding of western classical and Indian classical music; Time scales and rhythm in music and the handling of time in Physics; acoustics of auditoria – concepts of reverberation, echoes and good acoustics.	**12**
Unit-4	Physics of Dance : History of dance; main elements of western classical dance, Indian classical dance and modern dance; Physics of rotations and their application in western classical dancing; role of centre of gravity in the basic stances (plie and ardhamandala/araimandi) of the two forms; tension and its resolution; projectiles and jumps – elements of velocity, friction and angular momentum.	
Unit-5	Physics of Paintings/Photography: Introduction to electromagnetic spectra; colours and wavelengths; colour wheel, mixing of colours and complementary colors; symmetry and its role in nature; role of symmetry in paintings; the golden ratio; introduction to the Physics of cameras – parts of a camera; lenses and their properties; aperture, shutter speed and iso.	

Tasks and Assignments:

- **Reading/listening/viewing exercises for each unit**
- **At least 5 formative tasks and 3 formative assignments in addition to summative tests/exams**

References:

1. **Principles of Physics – Halliday, Resnick and Walker, 10th Ed Wiley (2015)**
2. **The Physics of Musical Instruments – N H Fletcher and T D Rossing, 2nd Ed, Springer, 2005**
3. **THE PHYSICS OF MUSIC AND MUSICAL INSTRUMENTS- D R Lapp – Online book http://kellerphysics.com/acoustics/Lapp.pdf**
4. **Physics and the Art of Dance: Understanding Movement – K Laws, M Swope and F Russel, Oxford University Press, 2002.**
5. **Art and Physics – Parallel Visions in Space, Time and Light – Leonard Shlain, William Morrow and Co, 1st Ed, 1991.**
6. **Physics of Digital Photography – Andy Rowlands, IOP Publishing, 2017.**

Course Outcomes

	Course Outcome	**Level**
CO 1	Understand the basics of (Indian) arts – music, dance and photography	Understand
CO 2	Apply concepts of basic Physics (and science) to further the appreciation of arts	Apply

CO 3	Analyze various art forms from a scientific point-of-view	Analyze
CO4	Extend the understanding to other art forms	Skill
CO5	Have a holistic view of the intersectionality of science and arts	Evaluate

General Objectives	Specific Objectives
Remember - retrieval of Information	List, Name, Define, Identify, Recall, Recognize, Tabulate, State, Repeat
Understand – demonstration of comprehension	Translate, Interpret, Extrapolate, Define in your own words, Differentiate, Cite example, Relate, Classify, Restate, Summarize, Locate
Apply – applying knowledge in a new context	Employ, Illustrate, Use, Solve
Analyze – supporting assertions through the use of evidence, identifying causes	Compare, Contrate, Criticize, Examine, Question, Test, Distinguish
Evaluate – coming to a judgement on the value of information	Predict, Select, Appraise, Find out,
Create – combining knowledge to come to new conclusions	Assemble, Construct, Develop, Formulate, Propose, Organize, Hypothesize
Skill	Arrange for the experiment, Experiment, Demonstrate, Verify the Hypothesis, Draw, Articulate

Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	✓	✓		✓	✓
CO2	✓			✓	✓
CO3	✓	✓		✓	✓
CO4	✓	✓		✓	✓
CO5	✓	✓	✓	✓	✓