DEPARTMENT OF PHYSICS

INDIAN INSTITUTE OF TECHNOLOGY (INDIAN SCHOOL OF MINES), DHANBAD

COURSE STRUCTURE & SYLLABUS

FOR

B. TECH. ENGINEERING PHYSICS (4-YEARS)

(Effective from 2019-2020)

First Year B. Tech. Engg. Physics

Semester-I/II

Subject	**L**	**T**	**P**	**Credit Hrs**
Mathematics-I	3	1	0	11
Physics	3	0	2	11
Basics of Electrical Engineering (modular)	3	0	3	6
Basics of Electronics Engineering (modular)	3	0	3	6
Engineering Graphics	1	0	3	6
Engineering Mechanics	3	1	0	11
Engineering Economics & Finance	2	0	0	6
NCC/NSS/NSO	S/X			
Total				**57**

Semester-I/II

Subject	**L**	**T**	**P**	**Credit Hrs**
Mathematics-II	3	1	0	11
Applied Chemistry	3	0	2	11
Numerical Methods (modular)	2	2	0	5
Computer Programming (modular)	2	1	2	5
Earth & Environmental Science	2	0	0	6
Manufacturing Processes	2	0	3	9
English Communication Skills	1	0	2	5
NCC/NSS/NSO, etc.	S/X			
Total				**52**

Second Year (Semester III)

Sl. No	Course Code	Name of the Course	L	T	P	Credit hours	Contact hours
1.	PHC200	Waves and Acoustics	3	0	0	9	3
2.	PHC201	Classical Mechanics	3	0	0	9	3
3.	PHC202	Mathematical Physics	3	0	0	9	3
4.	PHE200	E/SO (Biomedical Engineering)	3	0	0	9	3
5.	[To elect]	E/SO	3	0	0	9	3
6.	PHC203	Mechanics Lab	0	0	2	2	2
7.	PHC204	Waves and Acoustics Lab	0	0	2	2	2
Total Credit						**49**	**19**

Second Year (Semester IV)

Sl. No	Course Code	Name of the Course	L	T	P	Credit hours	Contact hours
1.	PHE202	E/SO (Material Science and Engineering)	3	0	0	9	3
2.	PHC205	Introduction to Quantum Mechanics	3	0	0	9	3
3.	PHC206	Applied Optics	3	0	0	9	3
4.	PHC207	Nuclear Science and Engineering	3	0	0	9	3
5.	PHC208	Electrodynamics	3	0	0	9	3
6.	PHC209	Optics Lab	0	0	2	2	2
7.	PHC210	Electricity and Magnetism Lab	0	0	2	2	2
Total Credit						**49**	**19**

Third Year (Semester V)

Sl. No	Course Code	Name of the Course	L	T	P	Credit hours	Contact hours
1.	PHC514	Statistical Mechanics	3	1	0	11	3
2.	PHC515	Laser Physics and Technology	3	0	0	9	3
3.	[To elect]	Open elective I[†]	3	0	0	9	3
4.	HSS1	HSS	3	0	0	9	3
5.	[To elect]	E/SO	3	0	0	9	3
6.	PHC300	Thermal Physics Lab	0	0	2	2	2
7.	PHC301	Electronics Lab	0	0	2	2	2
Total Credit						**51**	**19**

Third Year (Semester VI)

Sl. No	Course Code	Name of the Course	L	T	P	Credit hours	Contact hours
1.	PHC510	Atomic and Molecular Physics	3	1	0	11	3
2.	PHC302	Solid State Physics	3	0	0	9	3
3.	MS1	MS	3	0	0	9	3
4.	[To elect]	Open Elective II[†]	3	0	0	9	3
5.	[To elect]	Open Elective III[†]	3	0	0	9	3
6.	PHC303	Applied Optics Lab	0	0	2	2	2
7.	PHC304	Spectroscopy Lab	0	0	2	2	2
Total Credit						**51**	**19**

Fourth Year (Semester VII)

Sl. No	Course Code	Name of the Course	L	T	P	Credit hours	Contact hours
1.	[To elect]	Departmental Elective1*	3	0	0	9	3
2.	[To elect]	Departmental Elective2*	3	0	0	9	3
3.	[To elect]	Open Elective IV†	3	0	0	9	3
4.	[To elect]	Open Elective V†	3	0	0	9	3
5.	[To elect]	Open Elective VI†	3	0	0	9	3
6.	PHC400	UGP1	0	0	6	6	3
7.	PHS400	Internship/Training/Seminar/ Field excursion	0	0	0	S/X	3
Total Credit						**51**	**21**

Fourth Year (Semester VIII)

Sl. No	Course Code	Name of the Course	L	T	P	Credit hours	Contact hours
1.	[To elect]	Departmental Elective3*	3	0	0	9	3
2.	[To elect]	Departmental Elective4*	3	0	0	9	3
3.	[To elect]	Departmental Elective5*	3	0	0	9	3
4.	[To elect]	Open Elective VII†	3	0	0	9	3
5.	PHC401	UGP2	0	0	6	6	3
Total Credit						**42**	12

ESOs : One course (Biomedical Engineering) will be offered in monsoon and One course (Material Science and Engineering) will be offered in winter semester. Students of B. Tech Engg. Physics discipline have to take mandatorily the following two ESO subjects.

Sl. No	Course Code	Name of the Course	L	T	P	Credit hours	Contact hours
1.	PHE200	Biomedical Engineering	3	0	0	9	3
2.	PHE202	Material Science and Engineering	3	0	0	9	3

†**Open Electives (OEs) (Some courses will be offered in monsoon and others in winter semester):** The subjects to be floated as 'Open Electives' in a semester will be declared from the following table before semester registration. Students may choose one from the declared subjects from own department or any other subject available from sister departments.

Sl. No	Course Code	Name of the Course	L	T	P	Credit hours	Contact hours
1.	PHO300	Sensors and Transducers	3	0	0	9	3
2.	PHO301	Low Temperature Physics and Superconductivity	3	0	0	9	3
3.	PHO302	Introduction to Astrophysics and Astronomy	3	0	0	9	3
4.	PHO400	Nano electronics and Nano photonics	3	0	0	9	3
5.	PHO401	Introduction to Quantum Devices	3	0	0	9	3
6.	PHO402	Introduction to Biophysics	3	0	0	9	3
7.	PHO502	Nonlinear Optics	3	0	0	9	3

***Departmental Electives:** The subjects to be floated as 'Departmental Electives' in a semester will be declared from the following table before semester registration. Students should choose any two subjects (VII semester) and three subjects (VIII semester) from the declared list of subjects. To float a subject at least 25% students of the actual strength has to opt the subject.

Sl. No	Course Code	Name of the Course	L	T	P	Credit hours	Contact hours
1.	PHO503	Physics of Nanomaterials	3	0	0	9	3
2.	PHD400	Photonics and Optoelectronics	3	0	0	9	3
3.	PHD401	Optical Fiber Communication	3	0	0	9	3
4.	PHC505	Numerical Methods and Computer programming	3	0	0	9	3
5.	PHD506	Characterization Techniques	3	0	0	9	3
6.	PHD503	High Energy Physics	3	0	0	9	3
7.	PHD505	Thin Film and Vacuum Technology	3	0	0	9	3
8.	PHD502	Computational Physics	3	0	0	9	3
9.	PHD501	Advanced Quantum Mechanics	3	0	0	9	3
10.	PHD507	Plasma and Space Physics	3	0	0	9	3
11.	PHD509	Advanced Condensed Matter Physics	3	0	0	9	3
12.	PHD510	Quantum Computation and Information	3	0	0	9	3

COURSE CONTENT

SEMESTER-III

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC200**	**WAVES AND ACOUSTICS**	**3**	**0**	**0**	**09**

Course Objective

The objective of the course is to present an introduction to different types of oscillations and propagation of waves in different media and its effect. Much emphasis will be given on sound waves and its effect, application etc.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding of propagation of waves and its effects in different media.
- have a high-level understanding of modes of vibrations of coupled pendulum and also acoustics of buildings.
- be able to understand about the shock and seismic waves and its types.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Critical review on Oscillations: Lissajous figures; Small oscillations, Damped and forced oscillations, Amplitude resonances, Quality factor, linear and transverse oscillations of a mass between two springs; Two dimensional oscillator, Normal modes, Longitudinal and transverse oscillations of coupled masses, Energy transfer between modes, Coupled pendulum	12	Understanding of different types of oscillations: its superposition along and perpendicular direction, normal modes of vibration of coupled pendulum having longitudinal or transverse oscillation and energy transfer during oscillation
2	**Waves**: Wave motion; Wave velocity, Boundary conditions and normal modes, Dispersion relations, Dispersive waves, Acoustic and optical modes. Waves in continuous media, Waves in absorptive media; Energy density and energy transmission in waves, Normal and anomalous dispersions in waves, Group velocity and phase velocity; Bandwidth theorem. Superposition of waves: Linear homogeneous equations and the superposition principle, Interference in space and energy distribution; beats, Fog-signaling and Zones of silence	12	Understanding of propagation of waves and also motion of medium particles during the propagation, difference between normal and anomalous dispersion and finally about the propagation of matter waves. Understanding the difference between interference between two sound waves with time or space and its energy distribution.
3	**Acoustics:** Reflection and transmission of sound wave at a boundary between two media; Acoustic filters	3	This will help in understanding propagation of sound wave in two media and its effect at the interface. Idea of audio filter
4	**Ultrasonics:** Production, detection, properties and applications of ultrasonic waves; Acoustic grating.	3	Understanding of ultrasonic, infrasonic, supersonic waves and Uses of ultrasound
5	**Architectural acoustics**: Reverberation, Sabine's and Eyring's formula, Absorption of sound, Acoustical designs of rooms and auditorium, Presence of echoes, Focussing of sound, Echelon effect, Noise reduction and sound insulations; Acoustical measurements	6	Understanding of acoustics of room and auditorium. Concept of design of building for better audio system.
6	Shock waves, propagation of explosive sound, seismic waves	3	Understanding about earth quake and its source
	Total	**39**	

Textbooks:

1. Waves (Berkeley Physics Course, Vol. 3) by Frank S. Crawford Jr., McGraw-Hill, 1968.
2. Vibrations and Waves, A.P. French, CBS Publishers & Distributors, 2003.
3. Vibrations, Waves, and Acoustics, 8th Edition by D. Chattopadhyay and P. C. Rakshit, Books & Allied Ltd; 2010.

Reference Books:

1. Oscillations, Waves and Acoustics: by Mittal; I. K. International, 2010
2. Waves and Oscillations; N Subrahmanyam; Vikas Publication House Pvt Ltd; 1994
3. Waves and Oscillations; B K Mukherjee; Campus Books International; 2009
4. Oscillations and Waves; Satya Prakash; Pragati Prakashan; 2010
5. Waves and Oscillations: By R. N. Chaudhuri; New Age International, 2010
6. The Physics of Waves and Oscillations; Bajaj N K; Tata Mcgraw Hill; 2000.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC201**	**CLASSICAL MECHANICS**	**3**	**0**	**0**	**9**

Course Objective
The objective of the course is to educate students about the advanced methods to solve the problems of the mechanics of classical bodies and to introduce the basics of special theory of relativity.
Learning Outcomes
Upon successful completion of this course, students will: • have a broad understanding of the mechanics of classical objects. • have a understanding of advanced techniques of solving mechanics problems of classical objects. • be able to appreciate the limitations of classical mechanics.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Lagrangian Formulation:** Constraints and generalized Coordinates, degrees of freedom, D'Alembert's principle, Lagrange's equations from D'Alembert's principle, Hamilton's principle, Calculus of Variation and Lagrange's equations from Hamilton's principle. Conservation Theorems and Symmetry Properties, Simple applications of the Lagrangian formulation	9	At the end of this unit students should be able to use the advanced techniques of Lagrangian formulation to solve classical mechanical problems. They should be able to appreciate the versatility of the Lagrangian formulation in comparison to Newtonian Formulation.
2	**Motion in a non-inertial frame:** Motion of a point particle in a general (rigid) non-inertial frame of reference, centripetal acceleration, Pseudo force, Coriolis force and its applications, Galilean Relativity.	7	At the end of this unit students will be able to deal with the mechanics of bodies in non-inertial frames. In particular the motion of objects in rotating frames such as earth.
3	**Rigid body dynamics:** Degrees of freedom of a rigid body, Moment of inertia and their products, principal moments and axes, Orthogonal transformations, Euler angles, Euler's equations, Precessional motion, heavy symmetrical top.	7	At the end of this unit students should be able to understand the exact representation of the orientation of an arbitrary rigid body using Euler angles and its application in understanding the motion of heavy tops.
4	**Motion under central force:** Equivalent one body problem, Differential equation of an orbit, Kepler's law, Center of mass and laboratory coordinates, Scattering in center of mass and laboratory frames, Scattering cross-section, Rutherford scattering, Elastic and inelastic collisions.	7	At the end of this unit students will have the understanding of dealing with motion in central forces and it application in explaining the out of scattering experiments.
5	**Hamiltonian Formulation:** Definition of Hamiltonian, Legendre transformations, Hamilton equations and its application to simple cases, cyclic coordinates and conservation theorems, Canonical transformations, Poisson theorem, Poisson brackets.	9	At the end of this unit students should able to understand the use of Hamiltonian technique to solve mechanics problem. They should be able to appreciate the importance of canonical transformations in solving problems.
	Total	**39**	

Textbooks:

1. Classical Mechanics; Goldstein, Safko & Poole; Pearson; 2002.
2. Classical Mechanics, R. Douglas Gregory, Cambridge University Press, 2006.
3. Mechanics (Berkeley Physics Course, Vol. 1), 2nd Edition, C. Kittel, W. D. Knight, M. A. Ruderman, A. C. Helmholz, B. J. Moyer, McGraw-Hill Book Company, 1973.

Reference Books:

1. Mechanics and General Properties of Matter; P.K. Chakraborti, Kolkata Books and Allied; 2009
2. Classical Mechanics; J. C. Upadhyay; Himalaya Publication House; 2008.
3. Introduction to Classical Mechanics: With Problems and Solutions, 1st Edition, David Morin, Cambridge University Press, 2008.
4. Classical Mechanics, John R. Taylor, Univ Science Books, 2005.
5. Mechanics: Volume 1 (Course of Theoretical Physics), 3rd Edition, L. D. Landau and E.M. Lifshitz, Butterworth-Heinemann, 1982.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC202**	**MATHEMATICAL PHYSICS**	**3**	**0**	**0**	**9**

Course Objective
To sketch the ideas and emphasize the relations which are essential to the study of physics and related fields.
Learning Outcomes
The approach incorporate contents required for the basic & advanced level of understanding and active learning on problem solving skills of engineering students. The mathematical methods given herewith are not quoted under most general assumptions, but are customized to the more restricted applications required in almost all engineering courses.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Associated Legendre, Hermite and Laguerre polynomials; Generating functions and Differential equations; Recurrence relation; Physical applications; Green's function and its applications, Properties and representations of Dirac-delta function.	15	This will help students to solve varieties of problems in Spectroscopy, multipole expansion, quantum mechanics, time dependent and independent problems in physics.
2	Fourier transform: Development of complex Fourier transform, Sine, Cosine and complex transforms with examples, definition, properties of Fourier transforms, transforms of derivatives, Parseval's theorem, Convolution theorem, Momentum representation, Application of Fourier transformation to partial differential equations, discrete Fourier transforms, introduction to Fast Fourier Transforms.	9	This will help students to understand spectroscopic outcomes, quantum mechanics, signal processing, etc.
3	Group theory: Concept of group, examples of group: SU(2), O(3), abelian group, generators of finite group, cyclic group, group multiplication table, subgroup, conjugate elements and classes, isomorphism and homomorphism.	8	This is useful in the classification of molecules and crystals, understanding unification of different forces.
4	Tensors: Transformation properties, Metric tensor, Raising and lowering of indices, Contraction, Symmetric and anti-symmetric tensors.	7	To understand the theory of relativity, high energy physics, non-linear optics, quantum mechanics, etc.
	Total	**39**	

Textbooks:

1. Advanced Engineering Mathematics, 10th Edition, Erwin Kreyszig, Wiley, 2011.
2. Mathematical Methods for Physicists, Arfken & Weber, Academic Press, 2010.
3. Introduction to Mathematical Physics, Harper, PHI Learning; 2009

Reference Books:

1. Mathematical Methods in Physical Sciences; Boas; Wiley India Pvt Ltd; 2006.
2. Mathematical Physics; B.D. Gupta, Vikas Publishing House, 1986.
   Mathematical Physics: Advanced Topics; Joglekar, Universities Press, 2006.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC203**	**MECHANICS LAB**	**0**	**0**	**2**	**2**

Sl No.	Name of the experiments*
1	To determine Young's modulus of a material by bending of beam method.
2	To determine the modulus of rigidity of a wire by Static & dynamical method.
3	Determination of bending moment of a cantilever.
4	Calculation of coefficient of viscosity of a given fluid using Searle's Viscometer.
5	Measurement of contact angles of water and organic liquids on Teflon and glass substrates.
6	Determination of surface energy of a fluid by capillary rise method.
7	Determination of temperature coefficient of expansion/compressibility of solid/liquid/gas.
8	Measurement of contact angles of water and organic liquids on Teflon and glass substrates.
9	Determination of coefficient of static and dynamic friction using inclined surface.
10	Determination of coefficient of efflux of a given liquid using venturi meter.

*Any 8 experiments will be conducted.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC204**	**WAVES AND ACOUSTICS LAB**	**0**	**0**	**2**	**2**

Sl No.	Name of the experiments*
1	Determination of velocity of transverse wave in a stretched string.
2	Study of forced oscillation using Torsion pendulum (Pohl's pendulum).
3	Verification of principle of conservation of energy and momentum using oscillation apparatus.
4	Determination of speed of sound using Kundt's tube apparatus.
5	Determination of velocity of sound in air at room temperature by study of resonance in organic pipes.
6	Determination of *g* with compound pendula.
7	To determine the acceleration due to gravity by Kater's pendulum.
8	To determine ultrasonic velocity in liquid, density, compressibility of liquid using Ultrasonic interferometer
9	Study of Doppler effects in sound waves.
10	Study of electrical oscillation in an LCR circuit.

*Any 8 experiments will be conducted.

SEMESTER-IV

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	PHC205	INTRODUCTION TO QUANTUM MECHANICS	3	0	0	9

Course Objective
Course introduces the methods to do the mechanics of atomic and subatomic particles.
Learning Outcomes
Familiarizing students with the theoretical framework of non-relativistic quantum mechanics and its applications to simple problems.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: Wave-particle duality, notion of state vector and its probability interpretation	3	This topic covers the introduction to quantum mechanics.
2	Structure of Quantum Mechanics: Operators and observables, significance of eigen functions and eigenvalues, commutation relations, uncertainty principle, measurement in quantum theory.	4	This unit will help to understand operators, eigen functions, eigenvalues, uncertainty principle, etc.
3	Schrödinger Equation: Time-dependent Schrödinger equation, stationary states and their significance, time-independent Schrödinger equation;	4	In this topic, students will learn about the time independent and dependent Schrödinger Equation.
4	Potential Problems: Free-particle solution, Potential Barrier and tunneling, simple harmonic oscillator	4	Application of quantum mechanics to few simple problems are dealt with in this unit.
5	Motion in a central potential: Separation of variables in spherical polar coordinates, spherical harmonics, hydrogen atom problem.	4	Helps understanding the physics of atoms.
6	Representation Theory: Linear vector space, Dirac notations of Bra - Ket, Matrix representation of Observables and states, operators and their properties; unitary transformation, Parity and parity operators	5	New technique learned to solve quantum problems
7	Theory of Angular Momentum: Relation between rotation and angular momentum, Rotation operators, angular momentum algebra: commutation rules, Matrix representations, addition of angular momenta, spinors and Pauli spin matrices.	8	Helps understanding angular momentum and spin of particles.
8	Approximation Methods: Time-independent Perturbation theory: (non-degenerate and degenerate) and applications to fine structure splitting, WKB approximation; Variational method; Time-dependent perturbation theory, transition probability calculations, Fermi golden rule.	8	In this topic student will learn to solve practical quantum mechanical problems.
9	Scattering Theory: Introduction, partial wave analysis, Born approximation.	5	Helps to calculate the outcomes from experiments following rules of quantum mechanics
	Total	**39**	

Textbooks:

1. Introduction of Quantum Mechanics, Griffiths, Pearson Education, 2010.
2. Principles of Quantum Mechanics, R. Shankar, Plenum Press, 1994.
3. Quantum Mechanics: Theory and Applications, 1st Edition, Ghatak & Lokanathan, Kluwer Academic Publishers; 2004

Reference Books:

1. A Textbook of Quantum Mechanics, 2nd Edition, Mathews &. Venkatesan, McGraw Higher Ed, 2010.
2. Introduction to Quantum Mechanics; Pauling and Wilson, Dover Publications 1985.
3. Quantum Mechanics, Thankappan, New Age International Pub, 1993.
4. Quantum Mechanics 2nd Edition, Bransden & Joachain, Pearson, 2000.
5. Quantum Mechanics, 3rd Edition, Merzbacher, John Wiley; 2005.
6. Modern Quantum Mechanics, 2 edition, J.J. Sakurai, Pearson Education India, 2013.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC206**	**APPLIED OPTICS**	**3**	**0**	**0**	**9**

Course Objective
To teach students about basics of geometrical and physical optics, optical interference, diffraction, polarizations, double refraction and different types of interferometers and their applications. These are an extremely useful tool for optical physicist.
Learning Outcomes
After attending this course, students will learn the following: • Basics of geometrical and physical optics. • Broad understanding of interference, diffractions, polarization, double refraction and their applications. • High level understanding of different types of interferometric techniques and their uses in testing and measurements. • To familiarize with image forming system of lenses and human eye.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Geometrical Optics**: Fermat's principle, General Theory of Image formation, The Matrix Method in paraxial optics and its use in finding Translation, Refraction, System Matrix.	6	This unit answers the reasons of bending of light passing through different optical media along with image formation using Matrix method.
2	**Physical Optics**: Interference of light: The principle of superposition, two-slit interference, coherence requirement for the sources, optical path retardations, lateral shift of fringes, Localized fringes; thin films.	6	This unit will help student in understanding basics behind fringe formation/ measurement using classical two slits experiments and their applications.
3	**Fresnel diffraction:** Fresnel half-period zone plates, straight edge, rectilinear propagation; **Fraunhofer diffraction**: Diffraction at a slit, half-period zones, phasor diagram and integral calculus methods, the intensity distribution, diffraction at a circular aperture and a circular disc, Rayleigh criterion, **Diffraction gratings**: Diffraction at N parallel slits, intensity distribution, plane diffraction grating, Resolving power of a grating.	9	Starting with different types of diffractions, the topics will remind students of rectilinear propagation of light, uses of zone plates, single & n-slits and image formation using them.
4	**Double refraction and optical rotation:** Refraction in uniaxial crystals, its electromagnetic theory. Phase retardation plates, double image prism, polarization, Rotation of plane of polarization, origin of optical rotation in liquids and in crystals.	7	This section would help students to know the effect of propagation of light in anisotropic media and their practical applications.
5	**Applications:** Rayleigh refractometer, Michelson interferometer and its application for precision determination of wavelength, wavelength difference and the width of spectral lines. Intensity distribution in multiple beam interference, Fabry-Perot interferometer and etalon.	7	Through this part, students will come to know about different variant of interferometers and their practical uses in testing and measurements.
6	**Optical systems**: Characteristics of objectives, eyepieces, condensers for different applications. Human eye. Image manipulation by prism systems.	4	This will familiarize students about image forming system of lenses and basics of human eye.
	Total	**39**	

Text Books:

1. Fundamental of Optics, Jenkins and White; McGraw-Hill, 2001.
2. Optics, Ajoy Ghatak, Tata McGraw-Hill, 2005.

Reference Books:

1. Optics, Eugene Hecht; Addison-Wesley, 2001.
2. Principles of Optics, M. Born and E. Wolf; Cambridge University Press, 1999.
3. Geometrical and Physical Optics: P. K. Chakrabarti; New Central Book Agency; 2010.
4. Applied Optics and Optical Design; A.E. Conrady; Dover Publications; 2011.
5. Introduction to Applied Optics; Banerjee and Poon; CRC Press; 1991.
6. Optics and Optical Instruments; Johnson; Dover Publications; 2011.
7. Modern Optical Engineering, Warren Smith, McGraw-Hill Professional; 2007.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC207**	**NUCLEAR SCIENCE AND ENGINEERING**	**3**	**0**	**0**	**9**

Course Objective
The objective of the course is to discuss the basic of nucleus, its constituents, different model related to it, nuclear energy and its production, particle detectors and accelerators. We will also learn about fundamental particles.
Learning Outcomes
Upon successful completion of this course, students will: • have a broad understanding of the nuclear models, constituents of nucleus and its basic properties. • have a high-level understanding of the nuclear forces, nuclear reactions, nuclear decay, particle accelerators and detectors. • be able to know about fundamental particles e.g. fermions, leptons, baryons, mesons, neutrinos and antiparticles.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Basics of nucleus and its stability:** Nuclear binding energy, sizes, spins, angular momentum, magnetic moments, parity, quadrupole moments, energetic and stability against particle emission, Gamow's theory of Alpha decay, Fermi theory of Beta decay, Gamma decay	10	This topic covers of basics of nucleus, its fundamental properties, nuclear stability and theory of radio-active decays.
2	**Two Nucleon Problem:** Nature of nuclear forces, Meson theory of nuclear forces, Deuteron problem, Nucleon-Nucleon scattering, scattering length	6	This unit will help student to get knowledge about the nuclear forces and nuclear scattering.
3	**Nuclear model:** Liquid drop model, Shell model, Semi-empirical mass formula, Fermi-gas model.	3	In this topic, students will learn about different models of nucleus.
4	**Nuclear Reactions:** Conservation laws, Classification, Compound Nucleus theory, Continuum and Statistical theories, Cross-sections, Breit-Wigner formula, Direct Reactions.	6	This topic tells that different nuclear theory and nuclear reactions.
5	**Detectors & Accelerators:** Gas-Filled Ionization Detectors, Proportional counter, G.M. counter, Linear Accelerator, Synchrotron	4	This part will help to understand about acceleration of particles and its detection.
6	**Nuclear reactors:** Nuclear **fission**, critical size of reactor, general aspect of reactor design, classification of reactors, neutron moderation, Fissile and fissionable material, fast breeders, Nuclear **fusion**: Basic reactions and energetic, Lawson's criteria for fusion, Stellar fusion	6	In this topic, students will learn about the theory of production of nuclear energy, materials required to produce it.
7	**Elementary particles:** Leptons, Mesons and Baryons, concept of antiparticle, discrete symmetries and conservation laws, Isospin and strangeness	4	In this topic, students will learn about constituent of universe, different forces in nature, fundamental particles etc.
	Total	**39**	

Textbooks:

1. Nuclear Physics; I. Kaplan; Narosa; 2006
2. Introductory Nuclear Physics; Kenneth S. Krane; Wiley India Pvt Ltd; 2011
3. Modern Elementary Particle Physics, 2nd Edition, Gordon Kane, Cambridge University Press, 2017.

Reference Books:

1. Nuclear Physics; D. C. Tayal; Himalaya Publishing House; 2013
2. Quarks and Leptons; Halzen and Martin. Wiley India Pvt Ltd; 2008.
3. Nuclear Physics: Theory and Experiments; Roy & Nigam; New Age International; 2014
4. Theory of Nuclear Structure; S.K.Gupta; Alfa Publication; 2011

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC208**	**ELECTRODYNAMICS**	3	0	0	9

Course Objective
The Objective of the course is to teach students about the propagation of electromagnetic waves in linear media (vacuum, dielectric, and conductor).
Learning Outcomes
Upon successful completion of this course, students will: • Understand the concept of electrostatics and its applications with different principles. • Know the concept of magnetostatics and its applications with different laws. • Learn the principle behind the generation of electromagnetic waves. • Familiarize with different principles and phenomena when electromagnetic wave propagates in different media. • Have knowledge about the generation of electromagnetic radiation.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Electrostatics:** Differential form of electrostatic field equation, Poisson and Laplace equations, boundary value problems, Examples of image method and Green's function method, solutions of Laplace equation in cylindrical and spherical coordinates by orthogonal functions, dielectrics, polarization of a medium, electrostatic energy, Multipole Expansion.	12	The students will learn the concept of electrostatics and its applications with different principles.
2	**Magnetostatics:** Biot-Savart law, Ampère's law, differential equation for static magnetic field, vector potential, magnetic field from localized current distributions, examples of magnetostatic problems, Faraday's law of induction, magnetic energy of steady current distributions.	08	This unit will help students in understanding the concept of magnetostatics and its applications with different laws.
3	**Maxwell's Equations:** Displacement current, Maxwell's equations, vector and scalar potentials, gauge symmetry, Coulomb and Lorentz gauges, electromagnetic energy and momentum, conservation laws, inhomogeneous wave equation and Green's function solution. Plane waves in a dielectric medium, reflection and refraction at dielectric interfaces, frequency dispersion in dielectrics and metals, dielectric constant and anomalous dispersion, wave propagation in one dimension, group velocity, metallic wave guides, boundary conditions at metallic surfaces, propagation modes in wave guides, resonant modes in cavities.	17	This will help to learn the principle behind the generation of electromagnetic waves. Also students will familiarize with different principles and phenomena when electromagnetic wave propagates in different media like vacuum, dielectric and conductor.
4	Introduction to radiation theory	02	From this unit students will learn the principle behind the generation of electromagnetic radiation.
	Total	**39**	

Textbooks:

1. Introduction to Electrodynamics; Griffiths; PHI Learning; 2009
2. Classical Electrodynamics; J. D. Jackson; John Wiley; 2007
3. Classical Electrodynamics; Greiner; Springer; 1998

Reference Books:

1. Classical Electrodynamics, J. Schwinger, L. L. Deraad Jr., K. A. Milton, W.Y.Tsai, J. Norton, Westview Press, 1998.
2. Principles of Electrodynamics, Melvin M. Schwartz (Author), Dover Publications Inc., 1988.
3. Classical Electricity and Magnetism; Panofsky and Phillips; Dover Publications, Inc.; 1990
4. Electrodynamics of Continuous Media: Course of Theoretical Physics - Vol. 8, 2nd Edition, L.D. Landau and E.M. Lifshitz, Elsevier India, 2013.
5. Foundations of electromagnetic theory; Reitz, Milford & Christy; Pearson; 2009.
6. Classical Electromagnetic Theory; Vanderlinde; John Wiley & Sons; 1993.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC209**	**OPTICS LAB**	**0**	**0**	**2**	**2**

Sl No.	Name of the experiments*
1	Determination of wavelength of sodium light by Fresnel's bi-prism.
2	Determination of wavelength of sodium light by Newton's ring.
3	Identification of missing order in double slit diffraction pattern.
4	Determination of refractive index of various liquids and solids by Abbe Refractometer.
5	Fabry-Perot interferometer and etalon (finesse with laser).
6	To determine the focal length of the combination of two lenses and to verify the formula using nodal slide assembly.
7	Determination of refractive index using hollow prism and liquid prism.
8	Study of monochromatic aberrations of an optical system
9	Measurement of diameter of thin wire and groove spacing of CD by laser beam.
10	Determination of resolving power of a concave grating.

*Any 8 experiments will be conducted

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC210**	**ELECTRICITY AND MAGNETISM LAB**	**0**	**0**	**2**	**2**

Sl No.	Name of the experiments*
1	GM counter characteristics.
2	Verification of Ampere's law.
3	Design electromagnet with a hollow cylinder, torus, etc.., measure and verify (working formula) the on axis and off axis magnetic fields.
4	Determination of magnetic susceptibility of magnetic liquid.
5	To determine the value of inductance by using Anderson's bridge.
6	Determination of force between two Magnets
7	To verify the Thevenin and Norton theorems
8	Study of photodetector characteristics.
9	I-V characteristics of Si solar cell and calculation of efficiency.
10	Design coaxial cylindrical capacitor for measurement of density of dielectric liquid (oil).

*Any 8 experiments will be conducted

SEMESTER-V

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	PHC514	STATISTICAL MECHANICS	3	1	0	11

Course Objective
Systems, made up of large number of constituent particles are characteristic by many emergent properties which are understood by the laws of statistical mechanics. The course is meant to introduce these laws to the students.
Learning Outcomes
Students will be conversant with the general notions of Statistical Mechanics viz. ensemble theory. Using this approach they should be able to calculate properties of systems with many particles. They will also have the idea of the statistical basis of phase transitions and critical phenomena.

Unit No.	Topics to be Covered	Lecture Hours	Tutorial	Learning Outcome
1.	Phase space, trajectories and density of states, Liouville's theorem	2	1	At the end of this unit student will learn to represent a system of large number of particles with minimum as a point in phase space along with the time evolution of the system.
2.	Ensemble Theory: Microcanonical, Canonical and Grand canonical ensembles, partition function, calculation of statistical quantities, Energy and density fluctuations	8	3	This unit will introduce the concepts of the mathematical technique of ensemble theory to calculate the thermodynamics state of many body ststem.
3.	Density matrix, statistics of ensembles, statistics of indistinguishable particles	4	1	At the end of this unit students should be able understand the representation of quantum statistical systems.
4.	Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein condensation.	6	3	At the end of this unit student should be able to differentiate and explain between the behavior of Bosons and Fermions. They should be able to under the nature of such systems in extreme conditions.
5.	Cluster expansion for a classical gas, Virial equation of state	4	1	At the end of this unit students should be able understand the method to deal with many body interacting systems.
6.	Introduction of ising model: one, two and three dimensions; Exact solutions in one dimension	4	1	This unit will introduce first exactly solvable statistical model. Students should be able to appreciate the usefulness of such models in explaining the statistical mechanical methods.
7.	Landau theory of phase transition, critical indices, dimensional analysis.	4	1	At the end of this unit students should be able to understand the use of phenomenological theory of Landau to explain the phase transitions. The will also learn about universality and critical behavior of materials in certain thermodynamic conditions.
8.	Correlation of space-time dependent fluctuations, Fluctuations and transport phenomena, Brownian motion, Langevin theory, Fluctuation dissipation theorem, The Fokker Planck equation.	7	2	This unit will introduce the concepts of time dependent statistical mechanics. The students should be able to understand the concepts of fluctuations, transport phenomena and their understanding based on statistical approach.
	Total	**39**	**13**	

Text Books:

1. Statistical Mechanics: R. K. Pathria; Elsevier; 2002.
2. Fundamentals of Statistical and Thermal Physics; Reif; McGraw-Hill; 1965.
3. Thermodynamics and Statistical Mechanics; Greiner; Springer; 2007.

Reference Books:

1. Statistical Mechanics: K. Haung; Wiley Eastern; 2003.
2. Modern Theory of Critical Phenomena: Shang Keng Ma; Levant Books; 2007.
3. Statistical Mechanics: Landau and Lifshitz; Butterworth-Heinemann; 1976.
4. Introduction to Phase Transitions and Critical Phenomena; H. E Stanley; Oxford University Press; 1987.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC515**	**LASER PHYSICS AND TECHNOLOGY**	**3**	**0**	**0**	**9**

Course Objective

Laser, the light extraordinary, has so many applications in various field even having further potential and hence it has urgent need to familiarize lasers & their technical advances to the students so that students be ready to apply coherent light to solve various problems in areas such as scientific, industrial, healthcare etc.

Learning Outcomes

Through this course students will learn following:

- Fundamental principles of stimulated emission and how to convert it into coherent light emission.
- The manipulation of light i. e. mode selection, continuous and pulsed generation, spectral narrowing etc.
- Applications of various lasers in various fields including scientific research to common use.

Unit No.	Topics	Lecture Hours	Learning Outcome
1	Overview: Gaussian beam, Monochromaticity, Directionality, Coherence; Atomic energy levels.	4	In this section students will learn about fundamental properties of laser light.
2	Energy distributions and laser design: Einstein's quantum theory of radiation; Boltzmann distribution, Population inversion, Rate equations, Stability conditions, Three level and four level lasers; Issues in designing a laser; Pumping mechanisms; Stable and unstable resonators, Laser Cavity, Longitudinal and Transverse Modes, Mode Selection, Gain in a Regenerative Laser Cavity; Q-switching, Mode locking, Laser amplification, Frequency conversion, Pulse expansion, Pulse shortening – Pico-second and Femto-second operations, Spectral narrowing and Stabilization.	15	In this section students will learn basic principles of lasers, requirements for production of laser beams, pumping mechanism, modes and mode selection technique etc. Students will also learn laser pulse generation techniques.
3	Laser systems: Basics of tunable, ultrafast and power lasers; Gas lasers: He-Ne, He-Cd, Ar, Kr ion, CO2, Excimer lasers; Solid state lasers: Diode pumped solid state lasers, Lamp pumping and thermal issues; Ruby, Nd-YAG, Fibre lasers; Semiconductor lasers: Laser materials, Laser structure, Frequency control of laser output, Modern diode laser, Quantum cascade lasers, p-Ge lasers, Vertical-cavity surface-emitting laser.	14	In this section students will learn working of various important laser systems including semiconductor lasers
4	Applications of laser: Laser cooling; Laser barcode scanner, Laser trimming, Cutting, Welding, Drilling and Tracking, Pattern formation by laser etching; LIDAR; Laser-tissue interaction, Laser surgery; Holography, Interferometry, Microscopy.	6	In this section students will learn applications of lasers in various important fields

Text Books:

1. Laser Fundamentals, William T. Silfvast, Cambridge University Press, 2008.
2. Principles of Lasers, Orazio Svelto; Springer, 2009.
3. Lasers – Theory and Applications, K. Thyagarajan and A. K. Ghatak; Macmillan India, Delhi, 1981.

Reference Books:

1. Laser Physics, Simon Hooker and Colin Webb; Oxford, 2010.
2. Lasers, A. E. Siegman; University Science Books, 1986.
3. Laser Application in Surface Science and Technology, H. G. Rubahn; John Wiley and Sons, 1999.
4. Laser Physics, P. W. Milonni, J. W. Eberly; John Wiley and Sons, 2010.
5. Laser Cutting: Guide for manufacturing, C. L. Caristan; Society of Manufacturing Engineers, 2004.
6. Optical Electronics, Ghatakand Thyagarajan, Cambridge.
7. Essentials of Optoelectronics, A. Rogers, Chapman Hall.
8. Lasers and Non-Linear Optics, B. B. Laud; New Age International, New Delhi, 1991.
9. Laser Spectroscopy: Basic Concepts and Instrumentation, Demtroder; Springer, 2004.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC300**	**THERMAL PHYSICS LAB**	**0**	**0**	**2**	**2**

Sl No.	Name of the experiments*
1	To study characteristic of thermistor
2	Study of Seebeck effect and calibration of thermocouple.
3	Study of Peltier effect using a thermocouple.
4	To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.
5	Study of black body radiation and verification of Planck's Law.
6	Determination of ratio of specific heats of gas γ by Clark and Katz method.
7	To determine the specific heat of metal samples, and to determine the heat of fusion for ice.
8	Determination of Carnot efficiency using thermocouples.
9	Determination of Boltzmann's constant using *pn*-diode.
10	Verification of Joule's law of heating using Calorie meter.

*Any 8 experiments will be conducted

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC301**	**ELECTRONICS LAB**	**0**	**0**	**2**	**2**

Sl No.	Name of the experiments*
1	To determine the unknown resistance by the Wheatstone bridge.
2	Single stage and cascade amplifiers in CE and CB configuration.
3	Phase shift oscillator circuit design, current voltage characteristics and Q-factor.
4	Wein bridge oscillator.
5	Plot static characteristics of JFET and MOSFET. Determine the transistor parameters.
6	Operational amplifier as inverting and non-inverting amplifier.
7	Studying half adder and full adder by using logic gates.
8	Operational amplifier for mathematical operations (Differentiator and Integrator).
9	To design an astable and monostable multivibrator of given specification using 555 timers.
10	Asynchronous/synchronous counter.

*Any 8 experiments will be conducted

SEMESTER-VI

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	PHC510	ATOMIC AND MOLECULAR PHYSICS	3	1	0	11

Course Objective
Atomic and molecular physics topics covered here deals with the observation and interpretation of radiation absorbed or emitted by atoms or molecules. This information can lead into the knowledge of structure and properties of the atom/molecule.
Learning Outcomes
The course will enable the student to get an idea about atomic and molecular spectra, spin orbit interaction, fine and hyperfine structure of spectral lines, Zeeman and Stark effects, line broadening mechanisms, Raman spectra and Mossbauer spectroscopy.

Unit No.	Topics to be Covered	Lecture Hours	No. of tutorials	Learning Outcome
1	Vector atom model, Quantum states of one electron atoms-Atomic orbitals, Hydrogen spectrum-Pauli's principle.	4	1	This topic covers the introduction to atomic models, quantum states of hydrogen like atoms and hydrogen spectrum.
2	Spin orbit interaction and fine structure in alkali Spectra, intensity rules – Equivalent and non-equivalent electrons. Interaction energy in LS and jj Coupling – Hyperfine structure	6	3	This unit will help to understand the fine structure and hyperfine structure in atomic spectra and the interaction energy in L-S and j-j coupling.
3	Zeeman effect – Splitting of spectral lines in presence of weak and strong magnetic field, Stark effect, Two electron systems.	6	2	In this topic, students will learn about the removal of degeneracy using magnetic and electric fields.
4	Broadening of spectral lines– Line broadening, Doppler and Lorentz Broadening mechanisms.	3	1	The broadening of spectral lines is learned in this unit.
5	Molecular spectra, Rotational spectra of diatomic molecules as a rigid rotator using Schrodinger wave equation and non-rigid rotator, intensity of rotational lines, Frank-Condon principle.	6	2	This topic introduces molecular spectroscopy. The rotational spectra of diatomic molecules are explained quantum mechanically. It also discusses Frank-Condon principle.
6	Vibrational-rotational spectra, vibrational energy of diatomic molecule-Diatomic molecule as a simple harmonic oscillator, Effect of anharmonicity, Energy levels and spectrum-Morse potential, energy curve-Molecules as vibrating rotor-Vibration spectrum of diatomic molecule. Raman spectroscopy, Rotational and vibrational Raman spectra of diatomic molecules.	8	3	Vibrational-rotational spectra of diatomic molecules are learned in this unit. Raman spectroscopy of diatomic molecules are also considered here.
7	Effect of Nuclear spin on intensities of Rotational Raman spectra; Mossbauer spectroscopy.	6	1	The effect of nuclear spin in spectra is discussed in this unit.
	Total	**39**	**13**	

Text Books:

1. Introduction to Atomic Spectra; White; Mcgraw-Hill Education; 1934.
2. Atomic Spectra And Atomic Structure; Herzberg; Dover; 2008
3. Physics of Atoms and Molecules: Bransden and Joachain; Pearson; 2006.

Reference Books:

1. Fundamentals of Molecular Spectroscopy; Banwell; Mcgraw-Hill Education Ltd; 2000.
2. Introduction to Molecular Spectroscopy; Barrow; Mcgraw-Hill Education; 1962.
3. Lasers - Fundamentals and Applications: Thyagrajan & Ghatak; Springer; 2010.
4. Chemical Applications of Group Theory; Cotton; Wiley India Pvt Ltd; 2009.
5. Modern Spectroscopy; Hollas; Wiley India Pvt Ltd; 2010.
6. Atomic & Molecular Spectra; Raj Kumar, Kedar Nath, Ram Nath, New Delhi, 1997.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC302**	**SOLID STATE PHYSICS**	**3**	**0**	**0**	**9**

Course Objective
The objective of the course is to discuss the basic crystallography and physical properties of solids. Different theories related to free electrons in solids and to learn the electrical and magnetic properties of solids.
Learning Outcomes
Upon successful completion of this course, students will have/be able: • a broad understanding of the crystallography and to identify different crystal structures. • a high-level understanding of the bonding between the crystal and to know about band theory of solids. • to know about the free electron theory, lattice vibrations of solids. • to familiar with different electrical and magnetic properties of materials and their applications.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Crystallography: Crystal structure, fundamental translational vectors, unit cell, Wigner-Seitz cell, Symmetry elements, lattice types, lattice planes, Miller indices, Common crystal structure, Reciprocal lattice, Bragg's law and application.	6	This topic covers the basic crystal structure of solids. Students will be familiar with different types of crystal structures. They can learn to analyze the crystal system using Bragg's law and X-ray diffraction pattern.
2	Bonding in crystals: Potential between a pair of atoms; Lennard-Jones potential, concept of cohesive energy, covalent, Vander Waals, Crystal Defects.	5	This unit will help student to get knowledge about the different types of interatomic forces and bonding between the atoms. They will also learn about various types of defects that are usually present in a crystal.
3	Thermal properties: Lattice vibration, vibration of one dimensional monoatomic and diatomic linear chain of atoms, concept of phonons, Debye model.	5	In this topic, students will learn about the coupled vibration in lattices. Then they get familiar with phonon. Debye model is explained to describe the variation of lattice specific heat with temperature.
4	Free electron theory of metals: Drude-Lorentz theory, Sommerfield's Model, Fermi-Dirac Distribution, free electron concentration, electrical conductivity, Thermal Conductivity, Sommerfield theory of electrical conductivity.	6	This topic tells that the valance electrons move freely in any metal and it helps in conduction of electricity. Drude-Lorentz Theory and Sommerfield's Theory are discussed.
5	Band Structure: Electron in periodic potential: Bloch theorem, Kronig-Penney Model, energy bands.	4	This part will help to understand the potential experienced by an electron in a crystal. Bloch theorem, Kronig Penney model are used to describe periodic potential of an electron.
6	Dielectric properties: Static, electronic, ionic and orientational polarization, Lorentz internal field, dielectric loss and relaxation time.	5	In this topic, students will learn about the dielectric properties: dielectric loss, relaxation time, polarization etc. .
7	Piezo, Pyro, Ferro electric properties and application.	3	In this topic, students will learn about Pyroelectricity, Piezoelectricity and Ferroelectricity and their applications in various fields.
8	Magnetic Properties: Diamagnetic, Paramagnetic and Ferromagnetic Materials, Curie-Weiss law of susceptibility, Weiss Molecular field theory	5	In this part, different magnetic properties are such as diamagnetism, paramagnetism, ferromagnetism are discussed. Then Curie Weiss Law of magnetic susceptibility and Weiss molecular field theory are introduced.
Total		**39**	

Textbooks:

1. Introduction to Solid State Physics; C. Kittle; Wiley; 2012
2. Solid State Physics; Ashcroft and Mermin; Cengage Learning India Pvt Ltd; 2010
3. Elements of X-ray Diffraction, B.D. Cullity, Addison-Wesley Publishing Compony, INC., MA, USA 1956

Reference Books:

1. Solid State Physics: Structure and Properties of Materials; M.A. Wahab; Narosa; 2009
2. Solid State Physics; S. O. Pillai; New Age International; 2010
3. Elements of Solid State Physics; J. P. Srivastava; Prentice Hall of India; 2013

4. Solid State Physics; A. J. Dekker; Macmillan; 2010
5. Crystallography Applied to Solid State Physics; Verma & Srivastava; New Age; 1991

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC303**	**APPLIED OPTICS LAB**	**0**	**0**	**2**	**2**

Sl No.	Name of the experiments*
1	Determine the peak power and beam divergence of Laser beam.
2	Determination of bending loss in multi-mode fibers.
3	Michelson Interferometer (thickness of glass plate, refractive index).
4	Particle size determination by dynamic light scattering.
5	Determination of specific rotation of cane sugar solution using Laurent's polarimeter.
6	Study of Laser holography.
7	To determine wavelength of laser beam, refractive index of a transparent materials and refractive index change in air under different pressures using Mach-Zehnder interferometer
8	Michelson interferometer, determination of wavelength of light.
9	Determination of line widths of laser diodes and LEDs.
10	To analyze elliptically polarized Light by using a Babinet's compensator.

*Any 8 experiments will be conducted.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**PHC304**	**SPECTROSCOPY LAB**	**0**	**0**	**2**	**2**

Sl No.	Name of the experiments*
1	Determination of bandgap of a semiconductor using UV-Vis absorption.
2	Beer Lambert's law, concentration of solution.
3	Determine the plasma parameters of a gas using discharge tube.
4	To determine the Planck's constant using LEDs of at least 4 different colors.
5	To determine the wavelength of H-alpha emission line of Hydrogen atom.
6	Demonstration of Frank Hertz effect
7	Normal & anomalous Zeeman Effect
8	Determination of Hydrogen Deuterium splitting
9	Determination of e/m ratio.
10	X-ray, electron diffraction patterns, identification of crystal structure.

*Any 8 experiments will be conducted.

ESO SUBJECTS

Course Type	Course Code	Name of Course	L	T	P	Credit
ESO	**PHE200**	**BIOMEDICAL ENGINEERING**	**3**	**0**	**0**	**9**

Course Objective
The Objective of the course is to teach students about various biomedical processes and the primary role of a biomedical engineer.
Learning Outcomes
Upon successful completion of this course, students will: • Understand the role of a biomedical engineer in a modern health care system. • Have knowledge about human anatomy and physiology. • Learn various biomedical processes. • Get acquainted with different bio-instrumental tools, used to address health-related issues in our day to day life.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction**: What is Biomedical engineering? Modern health care system; Role of a Biomedical engineer; Recent advances and prospectus in future.	05	From this unit, students will learn about the role of a biomedical engineer in a modern health care system.
2	**Anatomy and Physiology**: Introduction; Cellular organization; Tissues; Major organ systems; Homeostasis; Biomolecules; Nucleic Acids; Proteins; communication systems; Engineering balances.	11	This unit will help students to learn about human anatomy and physiology.
3	**Biomechanics and biomolecular Engineering**: Prelude; Viscoelastic properties; Mechanics of Materials, Cells, Tissues, and Organs; Cardiovascular dynamics; Biomaterials and Artificial organs; Transport processes; Drug delivery; Tissue Engineering; Antigens, Antibodies, Clinical use of Antibodies, Vaccines.	13	Here students will know about various biomedical processes, their cause, effects, and remedy.
4	**Bioinstrumentation and Imaging**: Overview of measurement systems; Types of Sensors; Instruments in medical practice and the research laboratory; Biomicro electro-mechanical systems and lab-on-a-chip devices; X-rays and Ultrasound imaging; Magnetic Resonance Imaging (MRI), Computer Tomography (CT), Surgery; Nuclear medicine; Optical bio-imaging; Image processing and analysis.	10	The students get acquainted with different bio-instrumental tools and their use to address health-related issues in our day to day life.
	Total	**39**	

Text Books:
1. Biomedical Engineering - Bridging medicine and technology, W. M. Saltzman, Cambridge University Press, 2009.
2. Introduction to Biomedical Engineering, J. D. Enderle and J. D. Bronzino, Elsevier, 2012.

Reference Books:
1. Human Physiology - from cells to systems, L. Sherwood, Books/Cole, Cengage Learning.
2. Introduction to Biomedical Engineering, M. M. Domach, Prentice Hall, 2003.
3. Drug Delivery – Engineering principles for drug therapy, W. M. Saltzman, Oxford University Press, 2001.
4. Tissue Engineering – Principles for the design of replacement organs and tissues, W. M. Saltzman, Oxford University Press, 2004.
5. Introductory Biomechanics – From Cells to Organisms, C. R. Ethier, and C. A. Simmons, Cambridge University Press, 2009.
6. Biomedical Imaging: Principles and Applications, Ed: Reiner Salzer, Wiley, 2012.
7. Introduction to medical imaging, N. B. Smith, A. Webb, Cambridge University Press, 2011.

Course Type	Course Code	Name of Course	L	T	P	Credit
ESO	**PHE202**	**MATERIALS SCIENCE AND ENGINEERING**	**3**	**0**	**0**	**9**

Course Objective

To know the fundamental concepts of structure of engineering materials at nanoscale and possible technological applications in various fields of science and engineering.

Learning Outcomes

Upon successful completion of this course, students will:

- The students are able to perform and communicate the results of research.
- They have expertise in a field of study in synthesis, processing, characterization, and/or applications of materials.
- The students are able to identify and formulate advanced problems in materials engineering and apply knowledge of engineering to solve those problems.
- Learn to think and work like professional material scientists and engineers.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Structure of materials - crystal structure, microstructure; Diffusion; Phase diagram and phase transformation;	6	This topic covers the basic crystal structure of solids. Students will be familiar with different types of crystal structures. They can learn to analyze the phase transformation of the materials.
2	Material properties – mechanical, electrical, magnetic, physical, corrosion, thermal, optical properties; Processing of engineering materials;	6	This unit will help student to get knowledge about the different types of properties. They will also learn about various types of processing engineering materials
3	Material treatment – heat, surface; Failure and strengthening of metals; Alloys – metals, effects of different alloying elements, super alloys;	5	In this topic, students will learn about the heat, surface; Failure and strengthening of metals. Then they get familiar super alloys.
4	Ceramics – classification, characterization, properties; Polymers – classification, properties, processing;	5	This topic tells that the ceramics – classification, characterization, properties and it helps in classification, properties, processing; are discussed
5	Composite materials – structure, properties, classification, processing; Conductors, semi-conductors and magnetic materials – properties, production;	5	This part will help to understand the composite materials – structure, properties. Conductors, semi-conductors and magnetic materials – properties, production are to be discussed
6	Nanomaterials; Surface engineering and applications – techniques, coatings, processing and heat treatment; Materials classifications – engineering standards- materials selection;	6	In this topic, students will learn about the nanomaterials; Surface engineering and applications – techniques etc
7	Special materials -Deformation and fracture of materials Ductile/brittle behaviour, fracture toughness, creep, fatigue; Environmental impact; Reprocessing; Applications	6	In this part, special materials -deformation and fracture of materials Ductile/brittle behaviour are discussed. Then fracture toughness, creep, fatigue; Environmental impact; Reprocessing are introduced
	Total	**39**	

Text Books:

1. Solid State Physics, C. Kittel, 7th edition (Wiley Eastern)
2. Materials Science and Engineering, V. Raghavan (Prentice- Hall India)
3. Applied Physics for Engineers, Neeraj Mehta (PHI Learning, New Delhi)

Reference books:

1. Concept of Modern Physics, A. Beiser (Tata Mc-Graw Hill)
2. Solid State Physics, S.O. Pillai, 5th edition (New Age International)
3. Materials Science and Engineering: An Introduction, W.D. Callister, 6 th . Edn., Wiley, 2003
4. Introduction to Materials Science and Engineering Ralls, K., Courtney, T. H., and Wulff, J. John Wiley & Sons, 1976.

OPEN ELECTIVES

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	**PHO300**	**SENSOR AND TRANSDUCERS**	**3**	**0**	**0**	**9**

Course Objective
The main objective of the course is to give basic understanding about the various sensors and transducers. The details of fundamental principle and operation of various types of sensors and transducers will be given with emphasis on their applications in various fields.
Learning Outcomes
Upon successful completion of this course, students will: • have a broad understanding of various types of sensors and transducers. • have a thorough knowledge of the fundamental principle and operation of various types of sensors and transducers. • be able to apply various types of sensors and transducers in different applications/fields. • be able to calculate various types of parameter (like operational conditions, sensitivity, selectivity etc.) for different types of sensors and transducers.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Basics of sensors and transducers**: Principle, Classifications, Parameters: Characteristics, Environmental parameters.	4	This topic will give the idea about the various types of sensors and transduces along with related characteristics and parameters.
2	***Sensors:* Mechanical and Electromechanical sensors:** Resistive potentiometer, Inductive sensor, Capacitive sensor, Stress sensors, Ultrasonic sensors.	6	This unit will help student to get the basic principle of the different types of Mechanical and Electromechanical sensors.
3	**Thermal sensors:** Gas thermometric, Thermal expansion type thermometric, Resistance change type thermometric, Thermo-emf sensor.	4	This unit will help student to understand the fundamental principle of the different types of thermal sensors along with its properties.
4	**Magnetic sensors:** Magnetoresistive, Hall-Effect, Inductance, Eddy-current etc.	4	This section will help student to know the principle of operation of different types of Magnetic sensors along with its properties and applications.
5	**Radiation sensors:** Photodetectors, Photoelectric, Ionization Thermal radiation sensors , X-ray and Nuclear radiation sensors etc.	4	This topic will help student to get the basic principle of the different types of Radiation sensors.
6	**Electroanalytical sensors:** Electrochemical cell; Polarization; Electrodes Cell potential, Liquid junction etc.	4	In this topic, students will learn about the Electroanalytical sensors. They will also get familiar with various Electroanalytical parameters.
7	***Transducers:*** **Mechanical transducers:** Temperature, Pressure, Force, Torque, Flow measurements; Displacement-to-Pressure transducer, Seismic displacement transducer.	5	This part will mainly focus on various transduction principle. The details of different types of mechanical transducers and their operational principle will be discussed in detail.
8	**Active electrical transducers:** Piezoelectric, Electromechanical, Electrochemical transducers.	4	This topic will help student to get the basic principle of the different types of Active electrical transducers.
9	**Feedback transducer systems:** Amplifiers, oscillators, automatic control system	4	This part will summarize various types of Feedback transducer systems.
	Total	**39**	

Textbooks:

1. Sensors and Transducers by D. Patranabis; PHI, Eastern Economy Edition 2004.
2. Transducers and Instrumentation (2 Ed) by D. V. S. Murty, PHI Learning (2008)

Reference Books:

1. Sensors and Transducers by Ian Sinclair, Newnes, 3rd Edition 2001.
2. Sensors and Transducers by MJ Usher, Scholium International 1985.
3. Sensors and Transducers by Kieth Briendley, CRC Press 1988

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	**PHO301**	**LOW TEMPERATURE PHYSICS & SUPERCONDUCTIVITY**	**3**	**0**	**0**	**9**

Course Objectives
The course has the main objective of making the students familiar with the basic principle of various cooling techniques, basic ideas of superconducting materials and their applications.
Learning Outcomes
After studying this course the students will learn: (i) techniques for liquefaction and storage of air and inert gases, (ii) basics of superconductors, (iii) thermodynamics and electrical properties of superconductors, (iii) High temperature superconductors and (iv) applications of superconducting materials.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Liquefaction of gases, Expansion engines, operation principle and technical realizations, separation of liquefied gases, Inverse Carnot Engine, Joule-Thomson expansion, closed cycle refrigerators and Gifford-McMahon coolers, Pulse tube cooler, Liquid He cryostat. Basics of dilution refrigerator.	12	From this unit one can learn the basic principles of coolers, refrigerators and storages operating near absolute zero temperature.
2	**Basics of superconductivity**: Zero resistance, perfect diamagnetism, type-II super conductor (shubinkov phase), flux quantization, flux pinning, Josephson effects. **Thermodynamics of superconductors**: Condensation energy, entropy, specific heat capacity.	10	In this unit students will be familiar with electrical, magnetic and thermodynamic properties of superconducting materials.
3	**Electrodynamics of super conductors**: Drude model, London theory. BCS theory of superconductivity, properties of fermions and coherent states of fermions. Ginzburg-Landau theory, phase transition, screening, GL coherence length.	10	The learning outcome of this unit is the knowledge about the transport properties and the theory of phase transitions in superconducting materials.
4	**Applications:** Superconducting magnets, Magnetic levitation, application of Josephson junction, SQUID, high Tc superconductors.	7	After studying this unit the students will learn various industrial applications of superconducting materials and basics of high temperature superconductors.
	Total	**39**	

Textbooks:

1. Low-temperature Physics: An introduction for scientists and engineers, PVE McClintock, DJ Meredith, JK Wigmore; Springer Science 1992
2. Low-temperature Physics, C. Enss, S. Hunk linger, Springer-Verlag Berlin Heidelberg 2005
3. Experimental Techniques for Low temperature measurements, J W Ekin, Oxford Univ. Press 2006

Reference Books

1. Matters and Methods at Low-Temperatures, Frank Pobel, Springer-Verlag Berlin Heidelberg 2007
2. Introduction to Superconductivity, Michael Tinkham, Dover Publications; Second Edition; 2004

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	**PHO302**	**INTRODUCTION TO ASTROPHYSICS AND ASTRONOMY**	**3**	**0**	**0**	**9**

Course Objective
The objective of the course is • To provide a glimpse of the ever mysterious and stirring world of space and related phenomena to the beginners or to the curious students of any discipline other than physics; • To motivate students to choose a career in related areas of physics; • To prepare a base for an ambitious physics student who wants to go to advanced studies or research in relevant fields.
Learning Outcomes
Upon successful completion of this course, students will: • Able to understand various astrophysical phenomenon. • Eligible for higher studies in astronomy and astrophysics • will be familiar with the basic ideas and Stellar formation and evolution, and be able to apply current basic models.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Fundamentals:** Overview of major contents of universe, The scale of the universe: Mass, length and time scales in astrophysics, Celestial coordinates, Magnitude Scale, Sources of Astronomical information	6	This unit provides a broad knowledge of major celestial contents and basics of astronomical measurement.
2	**Basics of Astronomy**: Telescopes: Refracting and reflecting, Ground based and space based, Data handling, Astronomy in different bands of electromagnetic radiation: Optical, Radio, X-Ray Astronomy.	8	This unit gives a broad knowledge about different kind of instruments used for astronomical observation.
3	**Stellar Astrophysics**: Properties of Ordinary stars: Stellar colors, Stellar distances, basic knowledge of stellar atmospheres, Spectral types, Hertzprung-Russel Diagram.	7	This unit will help student in understanding Stellar Properties and classification.
4	Binaries, variable stars. Stellar Evolution, White dwarfs, Supernovae, Neutron Stars, Blackholes, Pulsars. Clusters of stars, open and globular clusters	8	Helps student in understanding Stellar formation and evolution, and be able to apply current basic models.
5	**Universe at large:** Galaxies, Types of galaxies. Normal and active galaxies, Shape, size and contents of Milky Way galaxy.	5	This unit is related to information regarding the major contents of the universe.
6	**Sun**: Basic Structure, Solar Corona, Chromosphere, Solar Activity, Solar wind.	5	Helps in the understanding of different solar phenomenon
	Total	**39**	

Textbooks:

1. Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press
2. Astronomy: A Physical Perspective, Marc L. Kutner
3. An Introduction to Astronomy and Astrophysics, Pankaj Jain, Taylor & Francis, 2015

Reference Books:

1. The Physical Universe, F. Shu, University of California, 1982.
2. Astrophysical Concepts, M. Harwit, 3rd edition, Springer-Verlag, 2006.
3. Elements of Space Physics, R. P. Singhal, PHI Learning, 2009

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	**PHO400**	**NANO ELECTRONICS AND NANO PHOTONICS**	**3**	**0**	**0**	**9**

Course Objective
To provide a broad knowledge of light-matter interaction and behavior of electronic transport properties in the materials at the nanoscale dimension.
Learning Outcomes
Upon successful completion of this course, students will: • Learn behavior of light at nanometer scale, and light interaction with nanoscale objects. • Learn behavior electron transport in the nanoscale metals and semiconductors • Provide the idea of exploring possible technologies with optical and electronic properties at nanoscale.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**NANOELECTRONICS** Review on electron energy bands in metals and semiconductor nanostructure, quantum confinement, 0D to 3D functional nanomaterials and hybrids.	5	This unit will provide the basic knowledge to understand the electrons behavior at nanomaterials and how it is drastically different from the bulk counterpart.
2	Electron transport in nanostructures: Classical dissipative transport, Dissipative transport in short structures, hot electrons, Classical and Quantum ballistic transport, Quantized conductance, Single-electron transport, and Coulomb blockade.	7	This unit describe the electron transport properties and their dependences in the dimensional properties of the nanomaterials.
4	Resonant-tunneling diodes, Single-electron-transistor, flexible optoelectronics devices, Nanoelectromechanical system.	5	The unit will introduce several electronic devices that exploit electrons transport properties at nanometer scale
5	**NANOPHOTONICS** Photons and Electrons, Optics at nanoscale, Energy transport by evanescent waves, Frustrated total internal reflection.	5	This unit will provide the basic knowledge of optics and how it is different at nanoscale dimension.
6	Dyadic Green's Function formulation for electric field, time-dependent Green's function, Maxwell's stress tensor, radiation pressure, forces in optical near fields.	10	This unit provide mathematical formulation are introduce to understand the light-matter interaction at nanometer scale.
7	Quantum emitters and detectors, Surface plasmons in nanostructures, Concept of SERS, Photonic crystal, Optical micro-resonators, Cavity enhanced absorption spectroscopy, nanoparticles for bioimaging applications.	7	This unit introduces several optical platform for their application in Photonic devices particularly in developing light emitters, detectors, optical sensors.
	Total	**39**	

Textbooks:

1. Introduction to Nanoelectronics, Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, Cambridge University Press (2008).
2. Nanophotonics, Paras N. Prasad, John Wiley & Sons (2004).

Reference Books:

1. Nanotechnology for Microelectronics and Optoelectronics, J.M. Martínez-Duart, R.J. Martín-Palma, F. Agulló-Rueda, Elsevier (2006).
2. Principles of nano-optics, Lukas Novotny and Bert Hecht, Cambridge University Press (2006).
3. Cavity enhanced Spectroscopy and Sensing, Edited by G. Gagliardi and H. P. Loock, Springer (2014).

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	**PHO401**	**INTRODUCTION TO QUANTUM DEVICES**	**3**	**0**	**0**	**9**

Course Objective
The objective of the course is to discuss the basic concepts related to the function of important quantum devises. Different quantum devises used in in the field of physics, electronics and optics have been highlighted.
Learning Outcomes
Upon successful completion of this course, students will: • have an conceptual understanding of quantum mechanical principles. • have a high-level understanding of instrumentation based on quantum mechanical principles. • be able to know the applications of different quantum devises used in various research fields • be able to familiar with the newly developed quantum computation and information technology.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Basics of quantum mechanics, Schrodinger wave equation, some potential well problems, tunneling and its applications	4	This topic covers the basic principles of quantum mechanics and few of its applications.
2	Electronic and optical properties of quantum solids: concepts of electron, phonon, excitons in quantum structures, DOS, energy bands, superlattices, Bloch oscillations, electronic transport in quantum structures, coulomb blockade, optical properties of quantum structures.	8	This unit will help student to understand basis solid state theory and the underlying principles used to explain different properties of solid, especially electronic and optical properties..
3	Quantum electronic devices: resonant tunneling diode, high electron mobility transistors, single electron transistor, Graphene FET.	7	In this topic, students will learn about the basic features of solid-state electronics and transport phenomenon.
4	Quantum optical device: Optical nanoresonators, double heterostructure laser, quantum cascade laser, quantum well LASER and LED, quantum dot infrared photodetectors, single photon detectors.	7	This topic focuses on the basic phenonemenon of light-matter interaction resulting in amazing concepts such as LASER, LED, Photodetectors, used in advanced optical devices.
5	Quantum magnetic device: Superconducting Quantum Interference Device, Superconducting Quantum Circuits, Superconducting Quantum Bits.	7	This part will help to understand the concept of different magnetic devices based on quantum mechanical principles and working at low-temperature. These devices are very much essential to measure different properties of superconducting and topological matters.
6	Introduction to quantum information processing: quantum bit, processing of qubit and their applications.	6	In this topic, students will learn about fundamental principle of quantum computation and information; the basics of the next-generation computer and communication technology..
	Total	**39**	

Text Books:

1. Physics of semiconductor devices, S.M. Sze.
2. Nanotechnology for Microelectronics and Optoelectronics, J.M. Martínez-Duart, R.J. Martín-Palma and F. Agulló-Rueda
3. Physics of Quantum Well Devices, B.R. Nag.

Reference Books:

1. Quantum Physics, H C Verma
2. The Physics of Low-Dimensional Semiconductors: An Introduction, John H. Davies

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	**PHO402**	**INTRODUCTION TO BIOPHYSICS**	**3**	**0**	**0**	**9**

Course Objective
The content of the course introduces the basic concept of biophysics and techniques used to address the biophysical problems to students.
Learning Outcomes
After completion of the course, students will: • Understand the impact of Physics to solve problems of Biological origin. • Have insight about numerous theoretical as well as experimental tools to address biological problems at the cellular level.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Basic Concepts**: General organization of a cell and its division; Kinetics and Transport processes; Molecular forces in biological structures; Physics of micro and macromolecules.	05	From this unit, students will learn the basics of biophysics.
2	**Biomolecules:** Biomolecular Structures and Dynamics (Proteins, Nuclear Acids, Carbohydrates, Lipids, and Membranes); Inter and Intra-molecular interactions; Molecular distribution & statistical thermodynamics; Computational biophysics.	15	Here students will learn about details of various structures and dynamics of cellular components.
3	**Optical Techniques**: Spectroscopic; Microscopic; Low and high coherence interferometry; Optical coherence tomography (OCT); Optical/Magnetic tweezers, Laser surgery.	13	From this unit, students will be acquainted about optical techniques used to address biological problems at the cellular level.
4	**Other Techniques**: X-rays and Ultrasound imaging; Magnetic resonance imaging (MRI), Computer tomography (CT), Scanning and Tunneling electron microscopy, Atomic force microscopy.	06	Here students will have knowledge about numerous theoretical as well as experimental non-optical tools used to address biological problems at the cellular level.
	Total	**39**	

Text Books:
1. Essentials of Biophysics, P Narayanan, 2005, New Age International.
2. Biomedical Imaging: Principles and Applications, Ed.: Reiner Salzer, 2012, Wiley.
3. Biophysics: An introduction, Rodney M. J. Cotterill, 2002, Wiley.

Reference Books:
1. Biophysics: An introduction, R. Glaser, 2012, Springer-Verlag Berlin Heidelberg.
2. Biophysics, V. Pattabhi & N. Gautham, 2002, Kluwer Academic Publishers.
3. Molecular and Cellular Biophysics, Meyer B Jackson, 2006, Cambridge
4. Biophysics, Ed. W. Hoppe, 1983, Springer-Verlag.
5. Applied Biophysics, A Molecular Approach for Physical Scientist, T.A Weigh, 2007, Wiley.
6. Introduction to Biomedical imaging, A. G. Webb, 2003, John Wiley & Sons Inc.
7. Magnetic Tweezers for Single-Molecule Experiments, I. D. Vilfan et. al., Ch. 13, pp. 371-395, Handbook of Single-Molecule Biophysics, 2009, Springer.

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	**PHO502**	**NONLINEAR OPTICS**	**3**	**0**	**0**	**9**

Course Objective
The course Objective is to teach students about the propagation of the electromagnetic wave in nonlinear media and the corresponding effects.
Learning Outcomes
After completing the course, students will: • Learn different nonlinear processes as an outcome under light-matter interaction in nonlinear media classically as well as quantum mechanically. • Have knowledge about the working principle of many optical devices based on nonlinear phenomena.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Origin of nonlinearity, Brief review of electromagnetic waves, Polarization, Diffraction, Anisotropic media, Light propagation through anisotropic media, Nonlinear polarization, Nonlinear susceptibility, Wave equation.	05	Here students will learn about the concept of nonlinear optics and the requirement of a suitable light source and medium
2	**Nonlinear Processes:** ***Second order nonlinear effects***: Second harmonic generation (SHG), Phase matching techniques, Periodically poled materials and their applications in nonlinear optical devices, Parametric fluorescence, Parametric amplification, Three wave mixing, Sum and Difference frequency generation, Parametric oscillation.	13	This unit will help students to learn different second order nonlinear processes as an outcome under light matter interaction in nonlinear media, Classically.
3	***Third order nonlinear effects***: Third harmonic generation (THG), Self-phase modulation, Cross-phase modulation, Four wave mixing, Optical phase conjugation, Kerr effect, Self-focusing and Self-defocusing. Spontaneous and Stimulated Raman Scattering, Hyper-Raman effect, Higher-order Raman processes,	12	From this unit students will learn different third order nonlinear processes as an outcome under light matter interaction in nonlinear media, Classically.
4	**Quantum-mechanical description**: Use of Density matrix and Perturbative approach to nonlinear optical susceptibilities. Multiphoton processes.	04	Here students will learn the Quantum mechanical description of different nonlinear processes.
5	**Devices**: Electro-optic effect, Electro-optic modulators. Photorefractive effect, Acousto-optic effect, Acousto-optic modulators. Magneto-optic effect. Faraday effect, Magneto-optic modulator, Quantum detectors.	05	From this unit students will understand the working principle of many optical devices based on nonlinear phenomena.
	Total	**39**	

Text Books:

1. Nonlinear Optics, R.W. Boyd, Academic press, Elsevier, 2008.
2. Quantum Electronics, Amnon Yariv, John Wiley and Sons, 1989.
3. Fundamentals of Nonlinear Optics, P. E. Powers, CRC Press, 2011.

Reference Books:

1. Nonlinear Optics; Nicolaas Bloembergen; World Scientific Pub Co Inc; 1996
2. Laser and Nonlinear Optics; B. B. Laud; New Age; 1991
3. Principles of Nonlinear Optics, Y. R. Shen, A Wiley Inter-science Publication, 1984.
4. Light-Matter Interactions, W. T. Hill and C. H. Lee, Wiley-VCH, 2007.
5. Essentials of Nonlinear Optics, Y. V. G. S. Murthy and C. Vijayan, Wiley, 2014.
6. Handbook of Nonlinear Optics, R. L. Sutherland, 2003.
7. Essentials of Lasers and Nonlinear Optics; Baruah; Pragati Prakashan; 2000.

DEPARTMENTAL ELECTIVES

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHO503**	**PHYSICS OF NANOMATERIALS**	**3**	**0**	**0**	**9**

Course Objectives
• To introduce the students with science and technology involved with the viable materials at nanoscale • To get the students ready for research in advanced fields of materials science and to be a professional in development and production industry.
Learning Outcomes
Upon completion a student will know about: • Properties of nanomaterials • Physical and chemical sciences working behind the properties exhibited by the materials at nanoscale; • Various physical and chemical techniques of synthesis and fabrication of nanomaterials and nanostructures • Some typical technologically important nanomaterials.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Band Structure, Density of States (DOS) in bands, Variation of DOS with energy, Variation of DOS and band gap with size of crystal; Joint Density of States, Dimensional dependence of DOS of Fermi gas electrons. Electron confinements in infinitely deep and finite square well potentials; Physical concepts of circular, parabolic and triangular well potentials.	8	After this unit being taught the students can learn the basic theoretical concepts essential for understanding the nanostrusctured materials.
2	**Quantum size effect:** Properties of nanoparticles, Characteristic lengths, Clusters, Magic Numbers; Quantum well, Quantum wire, Quantum dot; Energy subbands; Conduction electrons and dimensionality; Properties dependent on DOS. Electrical transport properties, Diffusive and ballistic regime, Single electron tunnelling, Excitons, Optical absorption in quantum well; Surface plasmon resonance; Nanomagnetism; Nanomechanical properties.	12	After studying this unit, one will learn about the most important forms of various nanostructured materials and some of their interesting properties.
3	**Preparation of nanomaterials and nanostructures**: Classification, Top-down and Bottom-up approach, Overview of different fabrication and synthesis techniques such as Ball Milling, Chemical bath Deposition, Electrodeposition, Sol-Gel, Anodization technique, Photolithography, E-beam lithography, Hot-embossing Technique, Physical Vapor Deposition, Glancing angle deposition, Pulsed Laser Deposition, Molecular Beam Epitaxy. Growth mechanisms of nanocrystals and nanostructures.	12	The main learning outcome of this unit is knowledge of various synthesis techniques for nanostructured materials.
4	**Typical nanomaterials**: Graphene, Fullerenes and Carbon Nanotubes; Supramolecular structures; Nanocomposites, Zeolites.	7	In this unit the properties of some new age novel nanomaterial will be discussed.
	Total	**39**	

Text Books:
1. Introduction to Nanotechnology, Poole and Owners, Wiley India Pvt Ltd, 2007.
2. Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, Cao; World Scientific Publishing Company, 2011.
3. Nanoscience and Nanotechnology – Fundamentals to Frontiers: M. S. Ramachandra Rao; Wiley, 2013.

Reference Books:
1. Handbook of Nanophysics – Principles and Methods: By Klaus D. Sattler; CRC Press, 2010.
2. Materials Science and Engineering: An Introduction, W. D. Callister, John Wiley and Sons, 2006.
3. Materials Science and Engineering, V. Raghvan, PHI Learning Pvt. Ltd., 2004.
4. Nanoscience and Nanotechnology in Engineering, V. K. Varadan, World Scientific, 2010.
5. Quantum Dots, Jacak, Hawrylak and Wojs, Springer, 1998.
6. Nanotechnology: Principles and fundamentals, Günter Schmid, Wiley-Vch, 2008.
7. Nanomaterials and Nanochemistry; C. Brchignac, P. Houdy and M. Lahmani; Springer, 2008.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHD400**	**PHOTONICS AND OPTOELECTRONICS**	**3**	**0**	**0**	**9**

Course Objective
Overall aim of this course is to give underlying physics principles of photonics and optoelectronics materials and devices. This course encompasses integration processes for optical, electrical and optoelectronic components for applications in present and future technologies in the areas of solid-state lighting, light wave communication, display, sensing etc. Further, technology and operation of a wide range of laser semiconductor devices will be discussed for their applications in optical telecommunications
Learning Outcomes
Upon successful completion of the course, students understand material optical properties and how it can be exploited to developed devices in the area photonics and optoelectronics. Student will also understand the functioning of most important optoelectronic devices, operational modes of photonic devices, which will enable to select suitable type of photonics and optoelectronics device for the given applications.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Light polarization, analysis of polarized waves, Optics of a single homogeneous and isotropic media, optics of periodic layer media, optics of anisotropic media, birefringence in anisotropic media, quarter- and half-wave plates	8	This unit will provide the basic knowledge
2.	Optical waveguide theory- asymmetric dielectric slab waveguides, couple mode theory. Introduction to photonic and plasmonic waveguides.	9	This unit will enable students to understand the basic theory of optical waveguides that includes photonic crystal, plasmonic waveguides.
3.	Optics of semiconductor quantum well and super lattice structure	2	The unit will introduce optical properties on 2D semiconductor nanostructures
4.	Interferometry: Fabry-Perot, thin-Film structures, holographic interferometry, Dielectric Mirrors, Optical Resonators, Negative refractive index and Metamaterials.	6	This unit will provide the basic knowledge of interferometry and optical resonators.
6.	Organic and inorganic semiconductor sources: photodiode, light emitting diodes, solar cells, quantum cascade lasers, photonic crystal laser.	8	This unit will provide the basic knowledge of Organic and inorganic semiconductor based optical sources.
7.	Quantum well photodetector, Organic and polymeric based photodetectors, Photo-emissive detectors, Thermal detectors.	6	This unit will provide the basic knowledge of Organic and inorganic semiconductor based optical detectors.
	Total	**39**	

Textbooks:
1. Physics of Optoelectronic Devices, Chuang, S. L., Wiley-Interscience, 1995.
2. Fundamentals of Photonics, Bahaa E. A. & Malvin Carl Teich, Wiley-Interscience, 2007

Reference Books:
1. Optics and Photonics:An Introduction, 2nd ed. , F. Graham Smith, Terry et. al, Wiley & Sons Ltd; 2007.
2. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Prentice-Hall; 2001.
3. Optics, Eugene Hecht, Addison-Wesley, 2001.
4. Optical waves in layered media, Pochi Yeh, Wiley, 2005.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHD401**	**OPTICAL FIBER COMMUNICATION**	**3**	**0**	**0**	**9**

Course Objective
Soon optical fiber communication is going to replace microwave communication and hence this subject is of great importance for engineering and science graduates. Course for this subject is prepared in a way that it could provide all the basic information that is needed to establish end to end communication with optical fibers.
Learning Outcomes
After completing the course, students will learn • Importance of optical communication over any other communication systems • Basics of light guiding in an optical waveguide, wave guide structures and their properties. • Introduction to various devices used in optical fiber communication such as light sources, detectors, optical amplifiers, multiplexers etc.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Light waves in a homogeneous medium, wave propagation in planner waveguide, cylindrical fiber, single and multimode waveguides, concept of TE and TM modes,	6	In this section students will learn basics of light propagation in various waveguide structures, modes formation and their consequences. to optics in isotropic and anisotropic materials.
2	Step-index fibers, numerical aperture, dispersion in single mode fibers, bit-rate, electrical and optical bandwidth, graded-index fibers, attenuation in optical fibers, decibels.	6	The students will also learn fundamentals of birefringence and optical anisotropy.
3	**Optical fibers cables and components:** Fiber fabrication methods, fiber-optic cables, optical fiber connections and losses, fiber splices, fiber connectors, optical amplifiers-semiconductor and erbium-doped fiber amplifiers.	7	In this section students will learn about fiber fabrication methods, optical losses and amplifiers.
4	**Optical sources**: Principles and characteristics of light emitting diodes (LED), heterojunction LEDs, internal and external quantum efficiency, LEDs for optical fiber communications, principle and characteristics of laser diode, heterostructure laser diodes, DBF laser, quantum-well laser.	7	This section devotes to various advanced light sources used in fiber communication, their working principles and characteristics. Students will learn it.
5	**Optical detectors:** Principle of p-n photodiode, quantum efficiency and responsivity, p-i-n photodiode, Avalanche photodiode, heterojunction photodiode, mid-infrared and far-infrared photodiodes.	7	In this section students will learn basics of the optical detectors and their specific uses in fiber communication.
6	**Fiber Optic Communication:** Fiber couplers, multiplexing strategies- optical TDM, FDM and WDM, hybrid multiplexing, coherent optical detection and communication and techniques.	6	This section introduces various devices/methods used to establish a good fiber communication. Students will learn about fiber couplers and multiplexing strategies.
	Total	**39**	

Textbooks:

1. An Introduction to Fiber Optics; Ajoy Ghatak, K. Thyagarajan; Cambridge University Press; 1998.
2. Fiber optics and optoelectronics, R.P. Khare, Oxford University Press; 2013.
3. Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Prentice-Hall; 2001.

Reference Books:

1. Optical Fiber Communications Principles and Practice, 3rd Edition, John M. Senior, Prentice Hall; 2009.
2. Integrated optoelectronics: Waveguide optics, Photonics, Semiconductors, Karl J. Ebeling, Springer; 2011
3. Optics, Eugene Hecht, Addison-Wesley; 2001.Optical waves in layered media, Pochi Yeh, Wiley, 2005.
4. Principles of Optics, Max Born & Emil Wolf, Cambridge University Press, 1999.
5. Physics of Optoelectronic Devices, Chuang, S. L., Wiley-Interscience, 1995.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	PHC505	NUMERICAL METHODS AND COMPUTER PROGRAMMING	3	0	0	9

Course Objective
The objective of the course is • to introduce students with the numerical procedures of fundamentals of mathematical operations and tools for computer programming; • To prepare them for coding in any language for applications in any physical field or subject.

Learning Outcomes
Upon successful completion of this course, students will: • Able to design numerical computer programming for various physical problems. • Numerically be able to accomplish the methods of approximation and errors, roots of equations, curve fitting, interpolation methods, calculus and Fourier approximation.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Methods of approximation and errors**: Truncation and round-off errors; Accuracy and precision.	3	Understand the cause of numerical errors and estimating numerical errors and idea about accuracy and precision.
2	**Computer Programming:** Computer programs in suitable languages, based on above topics.	6	Understand the basics of computer programs and writing it in MATLAB.
3	**Roots of Equations**: Bracketing methods (false position and bisection), Iteration methods (Newton-Raphson). Systems of linear algebraic equations: inversion and LU decomposition methods. Gauss elimination method.	6	Helps for numerical estimate the roots of equations using various method.
4	**Curve fitting:** Least squares regression, linear and nonlinear regressions.	5	Helps in the understanding the basics of curve fitting.
5	**Interpolation Methods:** interpolating polynomials. Newton's divided difference.	4	Helps in the understanding of interpolation method
6	**Numerical differentiation and integration:** Trapezoidal and Simpson's rules.	4	Helps to understand what constraints and triggers are for and how to use them.
7	**Ordinary differential equations:** Euler's method, Runge-Kutta methods. Boundary value and Eigenvalue problems. Partial differential equations: Laplace's equation and solutions. Few applications.	6	Helps to solve ordinary differential equations using various numerical methods.
8	**Fourier approximation:** Introduction, Discrete Fourier and Fast-Fourier transforms.	5	Helps to understand the numerical approximation using Fourier method.
	Total	**39**	

Text Books:

1. Shastry, S.S., "Numerical Methods", Prentice Hall Inc., India, 1998.
2. Richard L. Burden and J. Douglas Faires, “Numerical Analysis”, Brooks/Cole, Cengage Learning
3. Numerical Analysis with Algorithms and Programming; Santanu Saha, CRC press, 2016

Reference Books:

1. Noble Ben, "Numerical Methods", New York International Publications, New York, 1964.
2. Buckingham R.A., "Numerical Methods", Sir Isaac Pitman Sons. Ltd., London, 1957.
3. Uri M. Ascher and Chen Greif, “A first Course in Numerical Methods” SIAM, 2011.
4. Bakhvalov, N .S., "Numerical Methods", Mir. Pub., Moscow, 1977.
5. Numerical recipes in C++ or Fortran

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHD506**	**CHRACTERIZATION TECHNIQUES**	**3**	**0**	**0**	**9**

Course Objective

To make students acquaint with advanced materials characterization tools required for scientific research and development field.

Learning Outcomes

After completing the course, students will learn

- Basic principles and working of each technique.
- Methodology of data recording, analysis and interpretation of observations.
- How and when a particular technique needs to be used to get required information.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Microstructure Characterization techniques:** Light microscopy- bright field, dark field, phase contrast illumination, Ellipsometry, Spectral reflectance, Scanning Electron Microscope (SEM), Transmission electron microscope (TEM), Atomic force microscopy (AFM), Scanning tunnelling microscopy (STM).	6	In this section students will learn basics of instrumentation used to get microstructural information of samples.
2	**Spectroscopic techniques:** Spectrophotometry, Luminescence spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, Raman spectroscopy, Surface plasmon resonance (SPR) spectroscopy, Dynamic light scattering (DLS), Inductively Couple Plasma Mass Spectroscopy (ICPMS).	8	This section devotes to the spectroscopic tools used in characterization of various samples. Student will learn several important spectroscopic tools.
3	**Compositional characterization techniques:** X-ray and Ultra-violet Photoelectron Spectroscopy (XPS and UPS), Energy Dispersive X-ray analysis (EDAX), X-ray Fluorescence Spectroscopy (XRF), Rutherford Backscattering Spectroscopy (RBS), Inductively Coupled Plasma Mass Spectrometry (ICPMS).	7	Students in this section will learn techniques used to get compositional information of the samples.
4	**Crystalline Structure characterization techniques:** X-ray diffraction (XRD), Transmission Electron diffraction (TED).	2	It introduces X-ray based crystal structure analysis
5	**Electrical characterization techniques:** Measurement of resistivity by four-probe method, Impedance and ferroelectric measurements, flow cyclic voltammetry.	4	Student will learn basic electrical property measurement tools
6	**Characterization of Mechanical Properties:** Micro / Nanoindenter, Nanoindentation and bending tests by AFM, Frictional Force Microscopy.	4	It introduces techniques to get mechanical strength of the sample.
7	**Magnetic characterization techniques:** Vibrating Sample Magnetometer (VSM), Superconducting Quantum Interference Device (SQUID), and Magnetic Force Microscopy (MFM).	4	In this section students will learn magnetic property measurement tools
	Total	**39**	

Text Books:

1. Microstructural characterization of materials, D. Brandon and W. Kaplan, John Wiley and Sons, 2013.
2. Surface Characterization Methods: Principles, Techniques and Applications; Milling; CRC Press; 1999.
3. ASM Handbook: Volume 10: Materials Characterization; George M. Crankovic; ASM International; 1986.

Reference Books:

1. Encyclopaedia of Materials Characterization - Surfaces, Interfaces, Thin Films; Brundle, Richard, Evans and Shaun; Elsevier; 1992.
2. Characterization of Semiconductor Materials - Principles and Methods; McGuire; William Andrew Publishing / Noyes; 1989.
3. Optical Techniques for Solid-State Materials Characterization, Rohit P. Prasankumar, Antoinette J. Taylor, CRC Press, 2010.
4. Foundation of Spectroscopy. Simon Duckett and Bruce Gilbert. Oxford University Press. 2005.
5. Elements of X-ray Diffraction, Cullity B D., Stock S R, Prentice Hall, Inc. 2001.
6. Principles of Thermal Analysis and Calorimetry, Peter J. Haines, RSC, 2002.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHD503**	**HIGH ENERGY PHYSICS**	**3**	**0**	**0**	**9**

Course Objective
▪ To teach the students some high level physical concepts of sub-nuclear or particle physics; ▪ To specialize them for research on very advanced scientific problems of both experimental and theoretical physics in the area of fundamental nuclear particles and their interactions.
Learning Outcome
The course will let the students learn about fundamental particles, their interactions and conservations laws, quark model, different symmetries, Gauge theories, quantum electrodynamics and quantum chromodynamics.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Natural units; four fundamental interactions, leptons and hadrons, historical introduction to the elementary particles, Gell-Mann eightfold way	6	This unit will help students aware of elementary particles and its classification.
2	Quark model, Concept of colour, Bound states of quarks, Decays and conservation laws.	4	This topic will help students learn about various decays and conservation laws involving elementary particles.
3	Relativistic kinematics, Lorentz Covariance, Collisions.	5	This topic will help students understanding mechanism of particle colliders.
4	Symmetries and groups, SU(2) of Isospin, Flavour symmetries, SU(3) flavour group, construction of hadronic wave functions, Parity, Charge conjugation, CP violation, Weak Interactions.	10	This unit will help students various symmetries in terms of groups.
5	Gauge Theories, Lagrangians in relativistic field theory, Noether's theorem: symmetries and conservation laws, U(1) local gauge invariance and QED Lagrangian	5	In this unit, Students will about gauge theories and gauge interactions.
6	Non-Abelian Gauge Invariance, Yang-Mills Theory, Spontaneous Breaking of Gauge symmetry, Higgs Mechanism, Feynman diagrams and elementary particle dynamics	6	In this topic, students will learn about gauge invariance and Feynman diagrams of various fundamental interactions. .
7	Quantum Chromodynamics, The Standard Model, Grand Unification	3	This unit gives an overview of advanced topics like QCD and grand unification.
	Total	**39**	

Text Books:

1. Introduction to Elementary Particles, David J. Griffiths.
2. Introduction to High Energy Physics, Donald Perkins.
3. Quarks and Leptons: An Introductory Course in Modern Particle Physics, Francis Halzen and Alan Martin.

Reference Books:

1. Elementary Particle Physics, Stephen Gasiorowicz.
2. Relativistic Quantum Mechanics, James Bjorken and Sidney Drell.
3. Modern Elementary Particle Physics; Gordon Kane.
4. Gauge Theory of Elementary Particle Physics; T. P. Cheng and L. F. Lee, Oxford University Press 1984.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHD505**	**THIN FILM AND VACUUM TECHNOLOGY**	**3**	**0**	**0**	**9**

Course Objective

- To guide the students to the doorsteps of materials processing and device fabrication at micro and nanoscale, primarily using vacuum techniques – indispensable for miniaturization, reproducibility and reliability of the fabricated device;
- To prepare students with a specialized direction of materials science and engineering ready to land up in education, research, development and production useful for both in academia and industry.

Learning Outcomes

Students will learn:

- Theories of thin film growth from nano to micro scale, processes of growing thin films,
- Properties of materials at two dimensional structures and their possible applications,
- Theories and techniques of vacuum generation and measurements,
- Applications of vacuum from high pressure to ultra-low pressure.

Unit No.	Topics to Be Covered	Lecture Hours	Learning Outcome
1	Nucleation and Growth: Film formation and structure; Thermodynamics of nucleation, Nucleation theories: Capillarity model – homogeneous and heterogeneous nucleations, Atomistic model – Walton-Rhodin theory; Post-nucleation growth; Deposition parameters; Epitaxy; Thin film structure; Structural defects and their incorporation.	6	The theory and models of thin film growth, involved energetic, dependence of nucleation and growth on deposition parameters, microstructural models of thin films; formation of structural defects.
2	Preparation methods: Electrochemical Deposition (ECD); Spin coating; Physical Vapour Deposition (PVD)- thermal evaporation, electron beam evaporation, RF-sputtering; Pulsed Laser deposition (PLD); Chemical Vapour Deposition (CVD), Plasma-Enhanced CVD (PECVD), Atomic Layer Deposition (ALD), Molecular Beam Epitaxy (MBE).	6	Deposition or fabrication of thin films using various chemical and physical processes based on solution, vacuum, laser, plasma techniques yielding thin films with structural features ranging from course microstructure to atomically controlled layers.
3	Thickness measurement and monitoring: Electrical, mechanical, optical interference, microbalance, quartz crystal methods.	3	Various techniques of thin film thickness measurement and control.
4	Properties of thin films: Electrical, mechanical, optical and magnetic.	3	Important physical properties of thin films.
5	Thin film devices: Fabrication and applications.	2	Application oriented fabrication of thin film devices.
6	Vacuum principles: Basic terms and concepts; Continuum and Kinetic gas theory; Pressure ranges; Types of flow; Conductance.	5	Definitions of fundamental terminologies relevant to the subject; theories involved with gas flow in various levels of vacuum.
7	Vacuum generation: Vacuum pumps – a survey; Diaphragm pump, Rotary vane pump, Diffusion Pump, Turbomolecular Pump (TMP), Sorption pumps: Adsorption pumps, Sublimation pumps, Sputter-ion pumps; Cryo Pump.	7	Various techniques used to produce vacuum based on the principles of compression, condensation and gettering.
8	Vacuum measurement: Thermal conductivity vacuum gauges, Ionization vacuum gauges.	3	Techniques of vacuum measurement at various levels of pressure range.
9	Analysis of gas at low pressures: Residual gas analyzers, Quadrupole mass spectrometer.	2	Analysis of gases present in a closed chamber at high vacuum using different techniques.
10	Leaks and their detection: Types of leaks, Leak rate, leak size, mass flow; Leak detection methods: Pressure rise and drop tests, Tests using vacuum gauges, Bubble immersion test, Foam-spray test, Halogen and Helium leak detectors.	2	Various types of leaks observed in a vacuum chamber with varying levels of seriousness and their different detection procedures.
	Total	**39**	

Text Books:

1. Thin Film Phenomena; K. L. Chopra; McGraw-Hill; 1969.
2. Materials Science of Thin Films; Milton Ohring; Academic Press; 2001.
3. Fundamentals of Vacuum Technology; Walter Umrath; Leybold, 1998.

Reference Books:

1. Thin Films; Heavens; Dover Publications Inc.; 1991.
2. Thin-Film Deposition: Principles and Practice; Smith; McGraw-Hill; 1995.
3. Handbook of Vacuum Science and Technology; Hoffman, Singh and Thomas; Academic Press; 1998.
4. Vacuum Technology; Roth; North Holland, 1990.

5. Handbook of Thin Film Technology; Leon I. Maissel and Reinhard Glang; McGraw-Hill; 1970.
6. Thin Film Fundamentals; A. Goswami; New Age International Pvt. Ltd; 2007.
7. Vacuum Science and Technology; V. V. Rao, T. B. Ghosh and K. L. Chopra; Allied Publishers, 1998.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHD502**	**COMPUTATIONAL PHYSICS**	**3**	**0**	**0**	**9**

Course Objective
• To acquaint the students with highly developed computational methods employed in solving complex problems in physics; • To specialize them for research in theoretical physics in the forefront areas of advanced physical fields.
Learning Outcomes
After attending the course the students will learn about various computational techniques to solve physical problems. They will also be skilled on Monte Carlo and molecular dynamics simulations. Further they will have some useful concepts on parallel computation and MATLAB.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Theory and simulation of in one, two and three dimensions. Elementary ideas and simulations of self-avoiding walks,	4	Student will learn about the modeling and computation of lattice models and its applications in condensed matter physics.
2	Additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion.	4	The student will learn to deal with physical phenomena with random time evolution such as earthquack and stock market etc.
3	Percolation theory and simulation by Hoshen-Kopelman algorithm; Application to simple lattice models in Physics.	5	The student will learn with the behavior of connected clusters in a random graph describing phase transitions and its applications.
4	Introduction to Hartree-Fock theory and Density functional theory.	4	The student will learn about the DFT and its application in investigating the structural, magnatic and electronic properties of molecules, materials and defects.
5	Computer Simulations: Monte Carlo simulation: Basic idea, Importance Sampling, Metropolis algorithm, Markov chain, and Some applications.	8	At the end of this section of student will learn about the basic methods and tricks of Monte-Carlo simulation. They will also be able to perform MC simulation of simple molecular liquids.
6	Molecular Dynamics: Basic idea, Equation of motion; Program initialization, The force calculation, Integrating the equation of motion and Some applications. Ising model in magnetism, Bak-Tang-Wiesenfeld model in studies of self-organized criticality.	8	At the end of this unit student will learn about the methodology of the simulation of evolving systems. They will also learn about the application of Molecular Dynamic simulation of simple dynamic systems
7	Significance of Parallel Computation in numerical calculation; Introduction to MATLAB Programming with few examples.	6	At the end of this unit student should be able to know the methods and power of Parallel computing. They should be able to write small parallel computer codes.
	Total	**39**	

Text Books:
1. Numerical Recipes: The Art of Scientific Computing; William H. Press; Cambridge University Press; 2007.
2. A Guide to Monte Carlo Simulations in Statistical Physics, D. P. Landau and K. Binder, Cambridge University Press.
3. I. Prigogine and Stuart A. Rice, New Methods in Computational Quantum Mechanics, Wiley.
4. Introduction to Computational Chemistry, Frank Jensen

Reference Books:
1. Matlab: A Practical Introduction to Programming and Problem Solving; Stormy Attaway; Butterworth-Heinemann; 2011.
2. FORTRAN 90 for Scientists and Engineers; Brian Hahn; Butterworth-Heinemann; 1990.
3. Computer Programming in Fortran 77; V. Rajaraman
4. Computational Physics, Joseph Marie Thijssen, Cambridge University Press.
5. An Introduction to Computational Physics, Tao Pang, Cambridge University Press.
6. Computer Simulation of Liquids, M. P. Allen and D. J. Tildesley, Clarendon Press.
7. D. Frankel and B. Smit, Understanding Molecular Simulation, second edition, Academic Press.
8. R. G. Parr and W. Yang, Density Functional theory of atoms and molecules.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHD501**	**ADVANCED QUANTUM MECHANICS**	**3**	**0**	**0**	**9**

Course Objective
The introduces the concept of advanced quantum mechanics
Learning Outcomes
On successful completion of this course, students will: • be conversant with the concepts of scattering theory • relativistic quantum mechanics and • the idea of quantum field theory

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Scattering Theory: Scattering amplitude and cross-section, Partial wave analysis and application to simple cases; Integral form of scattering equation, Born approximation validity. The optical theorem.	9	This topic covers the quantum theory of potential scattering. Students will get familiarize with different approximations to solve Schrödinger equation for scattering problems.
2	Relativistic Quantum Mechanics: The Klein-Gordon equation. The Dirac equation. Dirac matrices, spinors. Magnetic Moment and Spin of electron; Positive and negative energy solutions, physical interpretation. Nonrelativistic limit of the Dirac equation.	10	This section helps student to understand the methods of relativistic quantum mechanics, spinors, magnetic moments, positive and negative energies, particle and anti-particle, etc.
3	Identical Particles: Symmetric and antisymmetric wave functions: Bosons and Fermians. symmetrization postulates, Pauli's exclusion Principle. Spin-statistics connection, self-consistent field approximation: Slater determinant, Hartree Fock method.	8	In this topic, students will learn about identical particles and obtaining wavefunction for Bosons and Fermions. This topic also covers the symmetrization postulates, Pauli's exclusion principle and solving the quantum mechanical problem using self-consistent field approximation and Hartree-Fock method.
4	Quantum Field Theory: Preliminaries: why QFT? Classical Field Theory; Lagrangian formulation; Action for a scalar field; Symmetries and conservation laws, Noether's theorem; Quantum equation for field, Canonical quantization of scalar field; Dirac Field; Fock space and particle number representation.	12	This topic covers the quantum field theory. After its completion student will be able to understand the principle of second quantization, use of Lagrangian density for solving field equations, concept of Canonical quantization of scalar field, Dirac Field, Fock space and particle number representation.
	Total	**39**	

Textbooks:

1. Relativistic Quantum Mechanics: Wave Equations, 3/Ed; Greiner; Springer Int.; 2006.
2. A First Book on Quantum Field Theory: Lahiri; Narosa Book Distributors Pvt Ltd; 2005.
3. An Introduction to Quantum Field Theory; Peskin and Schroeder; Westview Press; 1995.

Reference Books:

1. Relativistic Quantum Mechanics: Bjorken and Drell; McGraw-Hill; 1998.
2. Quantum Field Theory, Rev. Ed.; Mandl and Shaw; Wiley; 1993.
3. Modern Quantum Mechanics; Sakurai; Pearson; 1994.
4. Principles of Quantum Mechanics; Shankar; Springer; 2006.
5. Relativistic Quantum Mechanics and Quantum Fields; Katiyar; Campus Books Int.; 2009.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHD507**	**PLASMA AND SPACE PHYSICS**	**3**	**0**	**0**	**9**

Course Objective
To introduce students with the physics of terrestrial plasmas of gaseous systems and interactions of terrestrial atmosphere with solar system and to prepare them for advanced studies and research in similar fields.
Learning Outcomes
Upon successful completion of this course, students will: • Students will learn the physics of electron-ion interactions, fundamentals of plasmas, transport and electromagnetic wave propagation in plasma, their kinetics and applications. • They will also learn the effect of solar atmosphere on the atmosphere of earth.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Plasma Physics:** Introduction: Debye shielding, Plasma parameters, Applications of plasma physics.	2	In this topic students will learn basic properties of plasma and its applications
2	Single particle motions: Motion of charged particles in magnetic fields; Adiabatic invariants, Transit time magnetic pumping, Plasma heating; Plasma confinement schemes, Tokomak.	5	In this topic students will learn physics of motion of charged particles in magnetic fields which will make understand the plasma
3	Plasmas as Fluids: Fluid equation of motion, Plasma approximation.	2	Here students will learn dynamic of fluid by considering plasma as a fluid.
4	Waves in plasmas: Plasma oscillations, Electromagnetic waves in magnetized plasma, Wave propagation in cold and hot plasmas.	4	This section introduces generation and propagation of waves in plasma.
5	Diffusion and resistivity: Parameters; Collisions and discrete particle effects, Coulomb collisions, Transport processes, Conductivity, Diffusion along and across magnetic field; Fokker-Planck equation; Two-fluid and single-fluid magnetohydrodynamic (MHD) plasma models.	5	In this topic students will learn various transport properties of plasma and various theoretical models by considering plasma as a magnetic fluid.
6	Equilibrium and stability: Linear waves, fluctuations in a stable plasma and instabilities in magnetized plasma; Two-stream instability.	3	This topic will made able the understanding of plasma instability under certain perturbative forces
7	Kinetic theory: Velocity distribution, Equations of kinetic theory, Electron plasma waves and Landau damping; Solutions of Vlasov-Maxwell equation; Cyclotron damping.	4	Plasma kinetics deals with the relationship between velocity and forces and the study of plasma in velocity space. Students will be able to explain certain plasma behaviour using this theory.
8	**Space Physics:** Solar Phenomena: Structure of sun, Solar activity, Prominences, Coronal heating, Solar flares.	3	In this topic students will learn structure and properties of our Sun.
9	Solar wind: Properties, Solar wind formation, Interaction of solar wind with magnetized and unmagnetized planets.	3	In this topic students will learn the origin of solar wind and their propagation in space.
	Total	**39**	

Textbooks:

1. Basic Space Plasma Physics; Baumjohann & Treumann; World Scientific Publishing Co.; 1996
2. Space Plasma Physics: An Introduction; Das; Alpha Science International, Ltd; 2004
3. Plasma Physics and Introductory Courses; Dendy; Cambridge University Press; 1995

Reference Books:

1. Introduction to Plasma Physics and Controlled Fusion, Vol I; Chen; Springer; 2006
2. Principles of Plasma Processing; F F Chen, J. P. Chang; Plenum/Kluwer Publishers, 2002
3. Introduction of Plasma Physics; Goldston & Rutherford; Taylor & Francis Group; 1995
4. Fundamentals of Plasma Physics; Bittencourt; Springer; 2004

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHD509**	**ADVANCED CONDENSED MATTER PHYSICS**	**3**	**0**	**0**	**9**

Course Objective
The objective of the course is to introduce the basic theoretical background of condensed matter physics. To guide student to understand the underlying theories of advanced topics in condensed matter physics.
Learning Outcomes
Upon successful completion of this course, students will: • be acquainted with the basic theoretical knowledge about second quantization and many-electron theory • be able to know about localized disordered and correlated systems. • be able to familiar with the advanced theories of superconductivity and quantum Hall effect. • be acquainted with the basics of soft matter such as polymers, liquid crystal etc.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Many electron theory: Introduction to many-electron wave function, Hartree-Fock theory, Second quantization formalism; Interactions of Electrons and Phonons with Photons, Exciton and Polaritons.	8	This topic covers the basic theory of many-electron system such as Hartree-Fock theory. They will also learn about dynamics of quasi-particles such as photons, phonons, excitons and polaritons.
2	Localization in Disordered Systems: Electron Localization, Anderson localization, Mott’s Localization, Hopping Conductivity.	5	This unit will help student to get knowledge about localization phenomena in disordered system and their consequences giving rise to hopping conductivity.
3	Correlated Systems: Hubbard Model, Mott insulator, Kondo effect.	5	In this topic, students will learn about one of the key theories in condensed matter physics, the Hubbard model. They will also learn important phenomena such as Mott’s insulators, Kondo effect and so on.
4	Theory of Superconductivity: Flux quantization, Macroscopic Quantum interference, Cooper Pairing, Energy gap, BCS theory; Ginzburg-Landau theory; Introduction to high temperature superconductors.	11	This topic will teach them detailed theories of superconductivity in cluding BCS and GL theories. Moreover, it will also provide an introductory section about High-Tc superconductivity.
5	Quantum Hall Effect: Integer quantum Hall effect, Introduction to fractional QHE.	4	This part will help to understand the Nobel prize winning advanced topics such as integer and fractional quantum Hall effect and their basic theories.
6	Introduction to Soft Matter: What is Soft Condensed Matter: Qualitative discussion of Colloids, Polymers, Gels, Liquid crystals	6	In this topic, students will learn about different phenomena of soft condensed matter physics including colloids, polymers, liquid crystals, etc.
	Total	**39**	

Textbooks:

1. Many-Particle Physics; G. D. Mahan, Springer, 2000
2. Introduction to Condensed Matter Physics, F. Duan, J. Guojun, World Scientific.
3. Advanced Condensed Matter Physics, L. M. Sander, Cambridge.

Reference Books:

1. Basic notions of Condensed Matter Physics, P.W. Anderson, Perseus Books
2. Physics of Condensed Matter, P. K. Mishra, Academic Press, 2012.
3. Condensed matter field theory, Altland and Simmons , Cambridge
4. Quantum field theory and condensed Matter, R. Shankar,
5. Quantum approach to condensed matter physics, Taylor and Heinonen, Cambridge.
6. Soft Condensed Matter: Jones; Oxford University Press; 2002

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	**PHD510**	**QUANTUM COMPUTATION AND INFORMATION**	**3**	**0**	**0**	**9**

Course Objective
To introduce the basic knowledge about quantum computation and information
Learning Outcomes
On successful completion of this course, students will: • New dimension of quantum mechanics and its application in computer science • Information processing based on quantum mechanical principles • Quantum entanglement and quantum cryptography necessary for ultra-secured information passage

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Single qubit, multiple qbits, quantum gates, quantum circuits, Bell states, Bloch sphere, Density operators, Pure and mixed states, decoherence.	7	Introduction: Single qubit, multiple qbits, quantum gates, quantum circuits, Bell states, Bloch sphere, Density operators, Pure and mixed states, decoherence.
2	**Basics of quantum measurement:** Stern-Gerlach Experiment, Projective measurement, POVM measurement.	4	Because outlandishness of quantum mechanics could be understood through experiments, this unit will provide basic ideas about quantum measurements
3	**Quantum Algorithm:** Introduction to quantum algorithms, Deutsch-Jozsa algorithm, Grover's quantum search algorithm	6	This will help in understanding the basics of quantum algorithms proposed for quantum computers
4	**Quantum Cryptography:** Cryptography, Private key distribution, introduction to quantum cryptography. Quantum key distribution, No-cloning theorem, BB84, B92 protocols. Introduction to security proofs for these protocols. Quantum teleportation	10	This unit helps in understanding underlying principle of secure communication using quantum mechanical methods
	Quantum Information: Introduction to classical and quantum information, Examples of quantum error corrections, Shannon and Von Neumann entropy, Quantum channels and noises, Quantum correlations, EPR paradox, Bell's inequalities, Theory of quantum entanglement. Entanglement of pure bipartite states	12	This unit focuses on basic difference between classical and quantum information. It helps to understand information processing using quantum mechanical principles, basic techniques, new ideas

Text Books:

1. Quantum Computation and Quantum Information by M. A. Nielsen and I. L. Chuang, Cambridge University Press.

Reference Books:

1. A Short Introduction to Quantum Information and Quantum Computation by M. L. Bellac, Cambridge University Press.
2. Introduction to Quantum Computation and Information, H.-K. Lo, T. Spiller, S. Popescu, World Scientific, 1998
3. Principles of Quantum Computation and Information. Vol. 1, G.Benenti, G. Casati, G. Strini, World Scientific.