Master Program in Physics

Doon University

(Since 2015)

M.Sc. Physics 2 years' program

Course Structure

Semester I			
Course Code	**Title**	**Course Type**	**Credits**
PHC-401	Mathematical Physics	Compulsory	3
PHC-402	Classical Mechanics	Compulsory	3
PHC-403	Electromagnetic Theory	Compulsory	3
PHC-404	Quantum Mechanics I	Compulsory	3
PHC-405	Electronics	Compulsory	3
PHP-406	Lab I	Compulsory	6
	Total		21
Semester II			
PHC-451	Thermodynamics and Statistical Mechanics	Compulsory	3
PHC-452	Quantum Mechanics II	Compulsory	3
PHC-453	Solid State Physics	Compulsory	3
PHC-454	Atomic and Molecular Physics	Compulsory	3
PHC-455	Computational Physics	Compulsory	3
PHP-456	Lab II	Compulsory	6
	Total		21
Semester III			
PHC-501	Advanced Sol. State Phys.	Compulsory	4
PHC-502	Nuclear and Particle Physics	Compulsory	4
PHD-501*	Optoelectronics I (Lasers and Detectors)	Discipline Specific Elective	4
PHD-502*	Optoelectronics 2 (Optical Fiber communication, Integrated nonlinear optics)	Discipline Specific Elective	3
PHD-503*	Optoelectronics 3 (Applied Optics)	Discipline Specific Elective	3
PHD-504*	Nanotechnology	Discipline Specific Elective	3
PHD-505*	Atomistic Modelling and Simulations	Discipline Specific Elective	3
PHD-506*	Bio Physics	Discipline Specific Elective	3
PHD-507*	Computational Structural Biology	Discipline Specific Elective	3
PHE-501**	Research Methodology	Elective	3
PHC-504	Lab III	Compulsory	6
	Total		18
Semester IV			
PHP-551	Project	Compulsory	15
	Total		15
Total Credits in MSc 2 years			**75**

* any one course can be chosen from the mentioned elective courses in semester III.

** elective course at Masters level

Program Objectives:

1. To understand the underlying physics in the various subjects of the course including recent development in Physics.
2. To develop skills to design circuits and perform experiments in the laboratory.
3. To understand the importance of mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.
4. To inculcate the concepts of research through research and methodology course and encourage the students for research and development through dissertation project in the advanced areas of research.
5. To communicate the results of studies undertaken in the academic field of Physics accurately in a range of different contexts using the main concepts, constructs and techniques of the subject of Physics.
6. Use knowledge, understanding and skills in Physics for critical assessment of a wide range of ideas and complex problems and issues relating to the various sub fields of Physics.
7. To emphasize the importance of Physics as the most important discipline for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment.
8. To develop human resource with a solid foundation in theoretical and experimental aspects as a preparation for career in academia and industry.

Program Learning Outcomes:

The postgraduates in Physics should

1. have a coherent understanding and knowledge of basic and advanced concepts of the academic field of Physics.
2. Development of experimental skills by working on advanced systems along with theoretical and mathematical approaches to describing the physical world.
3. be capable of demonstrating ability to think and analyze rationally with modern and scientific outlook and identify ethical issues related to one's work, avoid unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism.
4. Develop communication skills and writing skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups.
5. Developing the skills to analyze the data and communicate their research work to any reputed journal.
6. be able to develop a national as well as international perspective for their career in the chosen field of the academic and research activities.

SEMESTER I

PHC-401: MATHEMATICAL PHYSICS

L	T	P	Cr
3	0	0	3

Course Objective:

1. To enable students, learn essential mathematical tools for solving physics problems at masters' level.
2. To enable to solve problems in complex analysis, vector spaces.
3. To understand the concepts of Fourier and Laplace transform.

Course Content:

Complex Analysis: Review of basic algebra and complex calculus; Singularities; Cauchy-Riemann relations; Cauchy's theorem, Taylor and Laurent series, Residue theorem; Contour integrals.

Vector spaces and Matrices: Linear Operators, Basic matrix algebra, Functions of Matrices, Special matrices and their properties, Eigen value and Eigen vectors, Diagonalization.

Fourier Transform and Laplace Transform: Properties, Odd and Even functions, Convolution and deconvolution, Correlation functions, Parseval's theorem, Fourier Transforms in higher dimensions; Properties of Laplace Transforms.

Ordinary Differential Equations (ODE): Review of ODE of higher orders, Series Solutions about an ordinary and about a regular singular point. Second solution, Polynomial solutions. Eigenfunction methods.

Special functions: Dirac Delta function, Legendre Functions, Spherical harmonics, Chebyshev Function, Bessel functions, Laguerre functions, Hermite functions.

Reference Books:

1. G.B. Arfken, Mathematical Methods for Physicists.
2. P. Dennery and A. Krzywicki, Mathematics for Physicists.
3. P.K. Chattopadhyay, Mathematical Physics.
4. A.W. Joshi, Matrices and Tensors in Physics.
5. R.V. Churchill and J.W. Brown, Complex Variables and Applications.
6. P.M. Morse and H. Feshbach, Methods of Theoretical Physics (Volume I & II).
7. M.R. Spiegel, Complex Variables.
8. Riley, Mathematical Methods for Physics and Engineering.

Course Learning Outcome:

After the successful completion of the course, the student,

1. will be able to learn basics of Complex Analysis, Vector spaces, matrices, Integral transforms, ordinary differential equations and special functions.
2. After this course students are capable to use the applications of these methods in basic physics problems.
3. Explain the concepts of differential equations and special functions.

PHC-402: CLASSICAL MECHANICS

L	T	P	Cr
3	0	0	3

Course Objective:

The course aims

1. To develop the idea of theoretical understanding of motion of a group of particles involving a wide range of length and energy scales.
2. To develop an understanding of Lagrangian and Hamiltonian formulation which allow for simplified treatments of many complex problems in classical mechanics and provides the foundation for the modern understanding of dynamics.

Course Content:

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

Two-Body Central Force Problem: Equation of motion and first integrals, classification of orbits, Kepler problem, scattering in central force field.

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

Special Theory of Relativity: Lorentz transformation, relativistic kinematics and dynamics, $E=mc^2$.

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

Reference Books:

- H. Goldstein, Classical Mechanics.
- L.D. Landau and E.M. Lifshitz, Mechanics.
- I.C. Percival and D. Richards, Introduction to Dynamics.
- J.V. Jose and E.J. Saletan, Classical Dynamics: A Contemporary Approach.
- E.T. Whittaker, A Treatise on the Analytical Dynamics of Particles and Rigid Bodies.
- N.C. Rana and P.S. Joag, Classical Mechanics.

Course Learning Outcome:

After successful completion of the course;

1. Students will be able to try finding solution of a time evolution of state of a system employing Lagrangian and Hamiltonian approaches.
2. The students will be able to apply the Variational principles to real physical problems.
3. Students will be able to understand the two-body central force problem and small oscillations problem in detail considering the direct applications in many systems at atomic to stellar scale.

PHC-403: ELECTROMATNETIC THEORY

L	T	P	Cr
3	0	0	3

Course Objective:

1. To make students understand the basic laws and applications of electromagnetic theory.
2. To evaluate fields and forces in using basic scientific method.
3. To provide concepts of relativistic electromagnetic theory and its applications in branches of Physical Sciences.

Course Content:

Electrostatics: Differential equation for electric field, Poisson and Laplace equations, formal solution for potential with Green's functions, 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.

Magnetostatics: Biot-Savart 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.

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.

Electromagnetic Waves: 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.

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

Covariant Formulation of Electrodynamics: Four-vectors relevant to electrodynamics, electromagnetic field tensor and Maxwell's equations, transformation of fields, fields of uniformly moving particles.

Concepts of Plasma Physics: Formation of plasma, Debye theory of screening, plasma oscillations, motion of charges in electromagnetic fields, magneto-plasma, plasma confinement, hydromagnetic waves.

Reference Books:

1. J.D. Jackson, Classical Electrodynamics.
2. D.J. Griffiths, Introduction to Electrodynamics.
3. J.R. Reitz, F.J. Milford and R.W. Christy, Foundations of Electromagnetic Theory.
4. W.K.H. Panofsky and M. Phillips, Classical Electricity and Magnetism.
5. F.F. Chen, Introduction to Plasma Physics and Controlled Fusion.

Course Learning Outcome:

After successful completion of course,

1. Students should be able to solve the problems of electrostatics and magnetism.
2. They should be able to learn and use the maxwell’s equations in possible applications.
3. The properties of radiation and its interaction with the matter, the special theoretical effects and concepts of plasma physics have been covered in this course.

PHC-404: QUANTUM MECHANICS – I

L	T	P	Cr
3	**0**	**0**	**3**

Course Objective:

1. To develop the basic understanding and mathematical formulation of Quantum mechanics.
2. To provide an understanding of the formalism and language of non-relativistic quantum mechanics.
3. To understand the theory of angular momentum.

Course Content:

Non- Relativistic Quantum Mechanics and Schrödinger Equation: A brief review of foundations of quantum mechanics, basic postulates of quantum mechanics, uncertainty relations, Schrodinger wave equation, expectation value and Ehrenfest theorem. Relationship between space and momentum representation. Applications: One dimensional potential step, tunneling, Hydrogen atom, particle in a three-dimensional box. **Operator formulation of Quantum Mechanics**: Vector representation of states, transformation of Hamiltonian with unitary matrix, representation of an operator, Hilbert space. Dirac bra and ket notation, Schrödinger, Heisenberg and interaction pictures. Relationship between Poisson brackets and commutation relations.

Theory of Angular momentum: Angular momentum; Commutation relations, eigenvalue spectrum, angular momentum, ladder operators and their matrix representation, addition of angular momentum, Concept of spin, Pauli spin matrices. Addition of angular momenta, Clebsch-Gordon coefficients and their properties, recursion relations.

Identical Particles: The Schrödinger equation for a system consisting of identical particles, symmetric and anti-symmetric wave functions, elementary theory of the ground state of two electron atoms; ortho-and Para-helium. Scattering of identical particles. Stern-Gerlach experiment.

Reference Books:

- D. J. Griffiths, Introduction to Quantum Mechanics (Pearson).
- J. J. Sakurai, Advanced Quantum Mechanics (Wesley).
- N. Zettili, Quantum Mechanics Concepts and Applications (Wiley)
- A. K. Ghatak and S. Lokanathan, Quantum Mechanics 3rded. (MacMillan).
- C. Cohen-Tannoudji, Quantum Mechanics (Volume I and II).

Course Learning Outcome:

1. After completing the course, the students should be able to understand the hypothesis and formulation of Quantum mechanics.
2. They should be able to solve the quantum mechanical systems involving central potential problem, small oscillation problem, Hydrogen atom problem, scattering and identical particles problems using the linear vector algebra and Dirac's notations.
3. The students will be able to grasp the concepts of spin and angular momentum, as well as their quantization and addition rules.
4. The students will be familiar with various approximation methods applied to atomic, nuclear and solid-state physics.

PHC-405: ELECTRONICS

L	T	P	Cr
3	0	3	0

Course Objective:

1. To develop an understanding of fundamentals of electronics in order to deepen the understanding of electronic devices that are part of the technologies that surround us.
2. To understand about the working and applications of various device such as amplifiers, operational amplifiers, logic circuits and flip-flops.

Course Content:

Review of basic semiconductor devices (diodes, transistors (i) p-n-p, (ii) n-p-n). Thevenin and Norton's theorem, Hybrid- & r- parameters, Biasing, current mirror, small signal Amplifiers, Feedback amplifiers, power amplifiers, JFET and MOSFET circuits.
Operational amplifiers DC coupled pairs, Differential amplifiers, its parameter, basic applications, Sinusoidal oscillators, Multi vibrators, Schmitt trigger, 555 IC timer, Clipping and clamping circuit, Sample and hold circuit, Active RC filter Power supplies and regulators, Power electronic circuits.
Basic logic gates, Boolean algebra, combinational logic gates, digital comparators, Flip flops, shift registers, counters, Analog to digital converters.
Microprocessor and microcontroller basics.

Reference Books:

- P. Horowitz and W. Hill, The Art of Electronics.
- J. Millman and A. Grabel, Microelectronics.

- J.J. Cathey, Schaum's Outline of Electronic Devices and Circuits.
- M. Forrest, Electronic Sensor Circuits and Projects.
- W. Kleitz, Digital Electronics: A Practical Approach.
- J.H. Moore, C.C. Davis and M.A. Coplan**,** Building Scientific Apparatus.

Course Learning Outcome:

After the successful completion of the course, the student should be able to learn

1. The concepts of microelectronics, introduction to the field effect transistors, identify its major properties and main types of FET and op-amps circuits.
2. The basics of digital circuits and the Boolean algebra involved.
3. Basics knowledge of microprocessors and microcontrollers.

PHP-406: LAB – I

L	T	P	Cr
6	0	0	6

Course Objective:

1. To provide the practical knowledge of experimental electronics.
2. Learn to acquire data in various experimental systems and to understand the use of various electronic systems.
3. To design a circuit on the bread-board for a particular experiment.
4. To keep the record of the experiments, performed in the laboratory.

Course Content:

1. To study the various digital analog circuits:
   4-bit discrete binary adder network, 8-bit DAC using 0808 IC without OP-amp.
2. To draw transfer characteristics of
   (a) An OP-amp (741IC) in inverting mode in close loop.
   (b) To determine offset voltage
   (c) To determine CMRR of the OP-amp
3. To determine the band gap of a semiconductor (Ge)
4. To study the amplitude modulation with the help of CRO
   (a) with I/O frequency at constant I/O voltage
   (b) To study variation of percentage of modulation with I/O voltage at constant I/O frequency.
   (c) Plotting modulated and demodulated wave
   (d) To determine carrier frequency

5. To study the frequency response of RC coupled amplifier
   (a) with feedback
   (b) without feedback
6. To perform various mathematical, logical and jump operations for 8 bit numbers using 8085 microprocessor.
7. To perform various mathematical, logical operations and jump operations for 16 bit numbers using 8085 microprocessors.

Course Learning Outcome:

1. Students will be able to design the adder circuit and analyze it.
2. Students will be able to design the Op-Amp circuit on the bread board by themselves and learn the characteristics of Op-Amp along with CMRR.
3. Students will gain the knowledge of CRO for various applications.
4. Students will be able to perform logical operations using microprocessor.

SEMESTER II

PHC-451: THERMODYNAMICS AND STATISTICAL MECHANICS

L	T	P	Cr
3	0	0	3

Course Objective:

1. To build the theoretical understanding towards the thermodynamics on the basis of underlying statistical formulation.
2. To have an understanding for the various aspects of equilibrium and non-equilibrium statistical physics.
3. To describe the features and examples of Maxwell-Boltzmann, Bose-Einstein and Fermi Dirac statistics

Course Content:

Elementary Probability theory: Binomial, Poisson and Gaussian distributions, central limit theorem.

Review of Thermodynamics: Extensive and intensive variables, laws of thermodynamics, Legendre transformations and thermodynamic potentials, Maxwell relations, applications of thermodynamics to (a) ideal gas, (b) magnetic material, and (c) dielectric material.

Formalism of Equilibrium Statistical Mechanics: Concept of phase space, Liouville's theorem, basic postulates of statistical mechanics, ensembles: microcanonical, canonical, grand canonical, and isobaric, connection to thermodynamics, fluctuations, applications of various ensembles, equation of state for a non-ideal gas, Van der Waals' equation of state, Meyer cluster expansion, virial coefficients.

Quantum Statistics: Fermi-Dirac and Bose-Einstein statistics. Applications of the formalism to:

(a) Ideal Bose gas, Debye theory of specific heat, properties of black-body radiation, Bose-Einstein condensation, experiments on atomic BEC, BEC in a harmonic potential.

(b) Ideal Fermi gas, properties of simple metals, Pauli paramagnetism, electronic specific heat and white dwarf stars.

Reference Books:

- F. Reif, Fundamentals of Statistical and Thermal Physics.
- K. Huang, Statistical Mechanics.
- R.K. Pathria, Statistical Mechanics.
- D.A. McQuarrie, Statistical Mechanics.
- S.K. Ma, Statistical Mechanics.

Course Learning Outcome:

1. Students shall be able to learn the basics of thermodynamics and the required mathematical tools.
2. A treatise to the derivation of such phenomenon is presented on the basis of statistical mechanical analysis employing classical and quantum mechanics-based approaches.

PHC-452: QUANTUM MECHANICS – II

L	T	P	Cr
3	0	0	3

Course Objective:

1. To grow the understanding of Quantum mechanics for more application point of view on the foundations of basics learned in the previous quantum mechanics' course.
2. To understand the concepts of the time-dependent perturbation theory and their applications to physical situations.
3. To understand the basics of scattering theory.

Course Content:

Time independent Perturbation Theory: Time independent perturbation theory for non-degenerate and degenerate systems upto second order perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogen atom, Zeeman effect with electron spin.

Variation principle, application to ground state of helium atom, electron interaction energy and extension of variational principle to excited states. WKB approximation: energy levels of a potential well, quantization rules.

Time Dependent Perturbation Theory: Time dependent perturbation theory, constant perturbation, Fermi Golden rule, coulomb excitation, sudden and adiabatic approximation, Harmonic perturbation, radiative transition in atoms, Semi-classical treatment of radiation, Einstein's A and B coefficients and spontaneous emission of radiation.

Scattering Theory: General considerations; kinematics, wave mechanical picture, scattering amplitude, differential and total cross-section. Green's function for scattering. Partial wave analysis: asymptotic behavior of partial waves, phase shifts, scattering amplitude in terms of phase shifts, cross-sections, optical theorem, phase shifts and its relation to potential, application to low energy scattering, exactly soluble problems; square-well, hard sphere, coulomb potential, Born approximation; its validity, Born series.

Relativistic Wave Equations: Generalization of the Schrödinger equation; Klein-Gordon equation and its drawbacks, plane wave solutions, charge and current densities, interaction with electromagnetic fields, Dirac's equation for a free particle, relativistic Hamiltonian, probability density, expectation values, Dirac gamma matrices, and their properties, non- relativistic limit of Dirac equation, plane wave solution, energy spectrum of hydrogen atom, electron spin and magnetic moment, Non conservation of orbital angular momentum and idea of spin, interpretation of negative energy and theory of positron.

Reference Books:

- D. J. Griffiths, Introduction to Quantum Mechanics (Pearson).
- J. J. Sakurai, Advanced Quantum Mechanics (Wesley).
- N. Zettili, Quantum Mechanics Concepts and Applications (Wiley)
- A. K. Ghatakh and S. Lokanathan, Quantum Mechanics 3rded. (MacMillan).
- L. I. Schiff, Quantum Mechanics (McGraw Hill).
- C. Cohen-Tannoudji, Quantum Mechanics (Volume I and II).

Course Learning Outcome:

1. Students shall be able to apply the quantum mechanical treatment to the more complex problems such as Perturbation theory, scattering theory and its applications to various possible simple potentials including relativistic effect in quantum mechanical treatment of a system.
2. The students will be familiar with various approximation methods applied to atomic, nuclear and solid-state physics.

PHC-453: Solid State Physics I

L	T	P	Cr
3	0	0	3

Course Objective:

1. To impart the extended knowledge of solid-state physics.
2. To understand the concept of structure in reference to properties of materials.

Course Content:

1. Crystalline and amorphous solids, crystal lattice, Basis vectors, Unit cell, Symmetry operations, Point groups and space groups, Plane lattices, and their symmetries. Three-dimensional crystal systems, Miller indices, Directions and planes in crystals. Interplanar spacings, Crystal structures: SC, FCC, BCC, HCP, NaCl, CsCl, Diamond and ZnS structure, Closed packed structures.

2. X-ray diffraction by crystals, Laue theory, Interpretation of Laue equations, Bragg's law, atomic scattering factor, Experimental methods of X-ray diffraction, Neutron and electron diffraction. Reciprocal lattice, Brillouin zones. Bragg's law in Reciprocal Space, Ewald construction.

3. Interatomic Forces and types of bonding. Ionic Bonds, Covalent bonds, Metallic bonds, Van der Waals' bonds, Hydrogen Bonds, Binding Energy of Ionic crystals, Cohesive energy of inert gas solids. Cohesive energy and bulk modulus of ionic crystals. Madelung constant, Lennard - Jones Potential.

4. Vibrations of one-dimensional monatomic and diatomic lattices. Infrared absorption in ionic crystals (one-dimensional model). Normal modes and phonons. Normal and Umclapp Process, Frequency distribution function, specific heat, Classical Theory and Einstein's Theory Lattice Specific Heat, Debye's theory of lattice specific heat. Anharmonic effects, Thermal Conductivity.

5. Drude-Lorentz's Classical Theory (Free electron Gas Model), Quantized free electron theory (Sommerfeld's Quantum Theory), Fermi energy, wave vector, velocity and temperature, Density of states. Electronic specific heats. Sommerfeld's model for metallic conduction

6. Energy bands in solids, The Bloch theorem, Bloch functions, Kroning-Penney model, Number of states in the band, Band gap in the nearly free electron model, The tight binding model, The fermi surface, Electron dynamics in an electric field, The effective mass, Concept of hole.

Reference Books:

- F.C.Phillips: An introduction to crystallography (wiley)(3rd edition)
- Introduction of Solids: L.V. Azaroff
- Solid State Physics-Structure and Properties of Materials: M.A. Wahab
- Solid State Physics: N.W. Ashcroft and N.D. Mermin
- C. Kittel: Solid-state physics (Wiley eastern)(5th edition).
- Charles A Wert and Robb M Thonson: Physics of Solids
- J. P. Srivastava: Elements of solid state physics (Prentice Hall India; 2nd edition)
- Christmaan-solid state physics (academic press)

Course Learning Outcome:

1. The students shall be able to learn the concepts of lattice and crystals, long range forces, X-ray diffraction, Vibrational analysis and concepts of phonons.
2. The quantum mechanical treatment of solids particularly focusing upon the study of the energy (states) as a function of spatial configuration of atoms.
3. The students will be able to formulate basic models for electrons and lattice vibrations for describing the physics of crystalline materials; and develop an understanding of relation between band structure and properties of a material.

PHC-454: ATOMIC AND MOLECULAR PHYSICS

L	T	P	Cr
3	0	0	3

Course Objective:

1. To make students understand the basic theory of spectroscopic techniques.
2. To understand the basic aspects of atomic and molecular physics.
3. To study spectroscopy of the multi-electron atoms and diatomic molecules.

Course Content:

Atomic Spectroscopy: Fine structure of Hydrogen lines, magnetic dipole moments, electron spin and vector atom model, identical particles, Pauli's exclusion principle, multielectron atoms-Hartree's self-consistent field theory, L-S and j-j coupling schemes, alkali atom spectra, equivalent and non-equivalent electrons, normal and anomalous Zeeman effect, Paschen Back Effect, hyper fine structure, Stark effect, width of spectral lines, X-ray spectra.

Molecular Spectroscopy: Born-Oppenheimer approximation, molecular orbital theory, rotational spectra of diatomic molecules, non-rigid rotator, vibrational spectra, anharmonic oscillator, explanation of rotational vibrational spectra in infrared, Raman effect and intensity alternation of the rotational bands, applications of infrared and Raman spectroscopy, electronic spectra of molecules, Fortrat Parabola, vibrational structure of electronic bands, Intensities of electronic transitions, Franck Condon principle, Condon parabola.

Reference Books:

- Atomic Spectra- H.E white, Cambridge University Press, Newyork, (1935).
- Atomic and molecular spectra: Laser- R. Kumar
- Fundamentals of Molecular Spectroscopy- C.B.Banewell
- Molecular Spectroscopy– A. Das
- Spectra of atoms and molecules- P. F. Bemath

Course Learning Outcome:

1. Students shall be able to understand the basics of atomic spectroscopy such as quantum mechanical hypothesis of atomic spectra, L-S and J-J coupling schemes, Zeeman effect, Stark effect, X-ray spectra etc.
2. Student will learn the quantum behavior of atoms in external electric and magnetic fields; and become familiar with the working principle of laser.

PHC-455: COMPUTATIONAL PHYSICS

L	T	P	Cr
2	0	1	3

Course Objective:

1. To enable students, learn the essentials of computational methods and techniques used to solve physics problems numerically.

Course Content:

Introduction to programming language: Overview of computer organization, hardware, software, scientific programming in FORTRAN and/or C, C++.

Numerical techniques: Interpolation, extrapolation, regression, numerical integration, quadrature, random number generation, linear algebra and matrix manipulations, inversion, diagonalization, eigenvectors and eigenvalues, integration of initial-value problems, Euler, Runge-Kutta, and Verlet schemes, root searching, optimization, fast Fourier transforms.

Reference Books:

- V. Rajaraman, Computer Programming in Fortran 77.
- W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, Numerical Recipes in FORTRAN 77: The Art of Scientific Computing. (Similar volumes in C, C++.)
- H.M. Antia, Numerical Methods for Scientists and Engineers.
- D.W. Heermann, Computer Simulation Methods in Theoretical Physics.
- H. Gould and J. Tobochnik, An Introduction to Computer Simulation Methods.
- J.M. Thijssen, Computational Physics.
- Riley, Mathematical Physics for Physics and Engineering.

Course Learning Outcome:

1. Students shall be able to learn a computer programming language and basics of computational methods in interpolation, root finding, differentiation, integration, eigenvalue determination, FFT, solution of differential equation etc.

PHP-456: LAB – II

L	T	P	Cr
0	0	6	6

Course Objective:

1. To make students learn the basics of physics through experimental methods.
2. To relate the theory through experiments of electronics and solid-state physics.
3. To analyze the data obtained through the experiments and keep the record of the experiments.
4. To expose the students to handle the experiments with confidence and ease.

Course Content:

1. To study a RC circuit as a low pass and high pass filter and study the RC circuit as a differentiator and an integrator.
2. To convert a micro ammeter into an ohm meter of different range and used to measure unknown resistance.

3. To study the variation of resistivity of Ge crystal with temperature by four probe method and hence to determine the band gap for it.
4. Determination of Plank’s constant using LED.
5. To study the Hall effect and hence to determine the Hall coefficient and Carrier concentration.
6. To determine the wavelength of laser using Michelson interferometer.

Course Learning Outcome:

1. Students will be able to study and understand the concept of low pass and high pass filters through RC circuits.
2. Students will be able to understand the concept of band gap through experiment and analyze it.
3. Students will learn and calculate the Hall coefficient, Hall angle, carrier concentration of Ge through Hall effect experiment.
4. Design and learn the circuit designing in the experimental lab through these experiments.
5. Learn to analyze the data.

SEMESTER III

PHC-501: SOLID STATE PHYSICS II

L	T	P	Cr
4	0	0	4

Course Objective:

1. To make students learn more about the theoretical models for studying condensed matter.
2. To enable the students to develop an understanding of relation between band structure and the electrical/optical properties of a material.
3. To introduce the concept of defects in materials with respect to structures.

Course Content:

1. Intrinsic and extrinsic semiconductors. carrier concentration and Fermi levels of intrinsic and extrinsic semi-conductors. Bandgap. Direct and indirect gap semiconductors. Hydrogenic model of impurity levels.
2. Band Theory (Advanced form Solid State Physics I), Tight Binding, Pseudo potential methods, De Haas-van Alphen Effect, AC conductivity and optical properties, plasma oscillations.
3. Defects in Crystals: Vacancy formation, Mechanism of Plastic deformation in solids, Stress Imperfections in crystals: Lattice defects & configurational entropy, vacancies, Schottky & Frankel pairs, Edge & screw dislocations (qualitative ideas), Frank-Read

Sources, Dislocations in FCC, BCC and HCP structures Experimental methods of detecting defects.

4. Magnetic properties of solids. Diamagnetism, Langevin equation. Quantum theory of paramagnetism. Curie law. Hund's rules. Paramagnetism in rare earth and iron group ions. Elementary idea of crystal field effects. Ferromagnetism. Curie-Weiss law. Heisenberg exchange interaction. Mean field theory. Antiferromagnetism. Neel point. Other kinds of magnetic order. Nuclear magnetic resonance, Hall effects, Elementary ideas of Quantum Hall effect, Cyclotron resonance and magnetoresistance
5. Superconductivity, Survey of important experimental results. Critical temperature. Meissner effect. Type I and type II superconductors. Thermodynamics of superconducting transition. London equation. London penetration depth. Basic ideas of BCS theory. High-T_c superconductors, Josephson junctions.
6. Superfluidity. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi crystals.

Reference Books:

- John Singleton: Band theory and Electronic properties of Solids (Oxford University Press; Oxford Master Series in Condensed Matter Physics).
- Ibach& Luth: Solid State Physics
- Elementary Dislocation Theory: Weertman and Weertman
- M. Ali Omar: Elementary solid state physics (Addison-wesley)
- C. Kittel: Solid-state physics (Wiley eastern)(5th edition)
- Solid State Physics, A.J.Dekker, Macmillan India Ltd
- Material Science & Engineering, V.Raghavan, Prentice –Hall of India, New Delhi (2001)

Course Learning Outcome:

Students shall be able

1. To grow their understanding about the quantitative hypotheses of energy levels, band gap computation based upon different approaches,
2. Understand the defects in crystals,
3. The students will learn the magnetic properties, superconductivity and superfluidity with reference to the structure of a materials.

PHC-502: NUCLEAR AND PARTICLE PHYSICS

L	T	P	Cr
4	0	0	4

Course Objective:

1. To understand the basics of nuclear physics and particle physics.

2. To provide an understanding of static properties of nuclei, nuclear decay modes, nuclear force and nuclear models.
3. To provide the understanding of basics of particle physics.

Course Content:

Nuclear Physics: Discovery of the nucleus, Rutherford formula, form factors, nuclear size, characteristics of nuclei, angular momentum, magnetic moment, parity, quadrupole moment. mass defect, binding-energy statistics, Weizsacker mass formula, nuclear stability, Alpha-decay, tunnelling theory, fission, liquid drop model. Nuclear forces, nucleon-nucleon scattering, deuteron problem, properties of nuclear potentials, Yukawa's hypothesis. Magic numbers, shell model, calculation of nuclear parameters, basic ideas of nuclear reactions.

Particle Physics: Relativistic quantum theory, Dirac's equation and its relativistic covariance, intrinsic spin and magnetic moment, negative energy solution and the concept of antiparticle. accelerators and detectors, discovery of mesons and strange particles, isospin and internal symmetries, neutrino oscillations, quarks, parity violation, K-mesons, CP violation.

Weak Interactions: Fermi's theory of beta-decay, basic ideas of gauge symmetry, spontaneous symmetry breaking, elements of electro-weak theory, discovery of W-bosons.

Strong Interactions: Deep inelastic scattering, scaling concepts, quark model interpretation, colour quantum number, asymptotic freedom, quark confinement, standard model.

Reference Books:

- G.D. Coughlan and J.E. Dodd, The Ideas of Particle Physics.
- D. Griffiths, Introduction to Elementary Particles.
- D.H. Perkins, Introduction to High Energy Physics.
- Kaplan, Nuclear Physics.
- R.R. Roy and B.P. Nigam, Nuclear Physics.
- M.A. Preston and R.K. Bhaduri, Structure of the Nucleus.
- M.G. Bowler, Nuclear Physics.

Course Learning Outcome:

1. Students shall be able to learn the basics theories and phenomenon of nuclear physics and particle physics involving relativistic quantum theory, mesons and strange particles, basic quantum numbers, weak and strong interactions.
2. The students will have an understanding of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of nuclear radiation with matter.

PHD-501: OPTOELECTRONICS I (LASERS AND DETECTORS)

L	T	P	Cr
4	0	0	0

Course Objective:

1. To make students learn the basic theories of optoelectronics particularly applied in Lasers and detectors.
2. To understand the concepts semiconductor laser sources.
3. To make the students understand about photo detectors.

Course Content:

1. Physics of interaction between Radiation and Atomic systems-stimulated emissions, line shape functions, Einstein Coefficients, Light Amplification, threshold condition, Laser Rate Equations, Two, three and four level systems. Line Broadening Mechanisms – Natural, Collision and Doppler, Theory of optical resonators – Fabry Perot Resonator, Modes of a Confocal resonator system, Planar resonator, General Spherical resonator, Gaussian Beam Propagation and ABCD law, Optical cavity stability criteria.

2. Losses in the cavity – quality factor, line width of the Laser, Mode selection – Transverse and longitudinal, Q – Switching – Peak Power, Total Energy, Pulse duration, Techniques for the control of laser output employing Q-switching, mode-locking and mode- dumping, **Laser Systems** – Ruby Laser, He-Ne Laser, Nd:YAG, Nd: Glass, CO_2 Laser, Excimer Laser, Fiber lasers, Properties of Lasers – Directionality, Coherence etc.

3. **Semiconductor Optical sources**: Direct and Indirect Band Gap semiconductors, Light source Material Heterojunction structure. Light Emitting Diode (LED) Laser Diodes (LD), Basics of Quantum dots, Quantum wire Laser and VCSELs, Distributed feedback laser (DFB), Distributed feedback reflector (DBR) laser.

4. **Photo Detectors:** Principle of operation, Performance parameters, Quantum efficiency, Responsibility, Cut off wave length, Photo detector Material. Frequency Response, Thermal Noise, Shot-Noise Signal to noise ratio, Noise Equivalent Power (NEP) structure of PIN and APD, CCD, LED and LCD display.

Reference Books:

- M. Born and E. Wolf, Principles of Optics, Macmillan, New York.
- A.K. Ghatak and K. Thyagarajan, Optical Electronics (Cambridge University Press)
- A Yariv, Quantum Electronics (John Wiley).

- K. Thyagarajan and A.K.Ghatak, Laser: Theory and Applications. (McMillan India. New Delhi)
- W.T. Silfvast, Laser Fundamentals, (Cambridge University Press).
- G.H.P. Thompson, Physics of Semiconductor laser Devices, (John Wiley & Sons)
- J. M. Senior, Optical fiber Communications, Principles & Practice, (Prentice Hall of India).
- G. Kaiser, Optical fiber Communications, McGraw Hill Book Company.
- AjoyGhatak, K. Thyagarajan, Introduction to Fiber optics.
- A. E. Siegman, Lasers
- Baa E Saleh, Fundamentals of Photonics

Course Learning Outcome:

1. Students will be able to study the matter-radiation interaction, basics of Lasers, and optical resonance, properties of electromagnetic waves in cavity, LED, LD, Quantum dots, DBR lasers, different displays etc.
2. To understand in detail about direct/indirect band gap in reference to optoelectronic applications.

PHD-502: OPTOELECTRONICS II (OPTICAL FIBER COMMUNICATION, INTEGRATED NONLINEAR OPTICS)

L	T	P	Cr
3	0	0	3

Course Objective:

1. To make students learn the basic theories of optoelectronics particularly applied in optical fiber and nonlinear optics.
2. To understand about the basics of optical fibers.

Course Content:

1. Introduction to optical fibers, Light guidance in an optical fiber, Numerical aperture, fiber types, Refractive index profiles, Concept of modes, Electromagnetic analysis of guided modes in an optical fiber. Concepts of Normalized Frequency, V-Parameter, Losses and Pulse dispersion in fibers. Pulse dispersion in single mode optical fibers, Concept of Dispersion shifted and Dispersion flattened Fibers, Fiber attenuation, Misalignment losses, Fiber material, Fiber fabrication, Splices & Connectors.

2. Electromagnetic analysis of guided modes in symmetric step index planar waveguides. Basic idea of asymmetric planar waveguides. Various kinds of channel waveguides - slab guide geometries: strip, raised strip, embedded strip, ridge, strip coated guides. Beam and waveguide couplers: Transverse couplers, the prism-coupler, the Grating coupler, the thin-film tapered coupler, wave guide-to-fiber couplers. Electro-optic Effects, Acousto-optic Effect, Raman-Nath, Acousto-optic modulator, Bragg modulator, Acousto-optic deflectors, Acousto-optic spectrum analyzer.

3. Origin of non-linear optical effects. Wave propagation in a nonlinear media. Nonlinear Optical susceptibility. Second harmonic generation and phase matching techniques. Physical phenomena related to 2nd order and 3rd order susceptibility, three wave interaction, sum and difference generation. Manley Rowe relations, Parametric conversion and amplification. Basic idea of optical phase conjugation, Introduction to Nonlinear effects in optical fibers.

Reference Books:

- A.K. Ghatak and K. Thyagarajan, Optical Electronics (Cambridge University Press)
- A. Yariv, Quantum Electronics (John Wiley).
- J. M. Senior, Optical fiber Communications, Principles & Practice, (Prentice Hall of India).
- G. Kaiser, Optical fiber Communications, McGraw Hill Book Company.
- Ajoy Ghatak, K. Thyagarajan, Introduction to Fiber optics.
- D. Marcuse: Theory of Dielectric Optical waveguides, (Academic press, New York).
- Nishihara, Integrated Optical Circuits
- N.S. Kapani: Fibre Optics (Academic Press, New York).
- Y. R. Shen, The principles of Nonlinear Optics (Wiley, New York)
- R. W. Boyd, Nonlinear Optics

Course Learning Outcome:

1. Students will be able to understand the basics of optical fibers and light propagation through it, fiber attenuation, Fiber fabrication, waveguides and nonlinear optical effects, SHG phenomenon and its applications.

2. Student will learn about the wave propagation in nonlinear media and their effects in optical fibers.

PHD-503: OPTOELECTRONICS (APPLIED OPTICS)

L	T	P	Cr
3	0	0	3

Course Objective:

1. To impart knowledge about the applied optics in the field of optoelectronics.

Course Content:

1. Conventional versus holographic photography, Hologram of a point source, hologram of an extended object, Off-axis technique in the recording of holograms. Three dimensional holograms – Reflection holograms. Basic idea of holographic data storage, Holographic interferometry – double exposure, real time, time average holographic interferometry. Optical correlation. Fourier Transform holograms and their use in character recognition.

2. Introduction to Optical data processing, Abbe's theory. Spatial filters – low pass, high pass, band pass filters. Fraunhofer Diffraction and the Fourier Transform – mathematical concept. Young's experiment. Michelson Stellar interferometer and its limitation. Hanbury Brown and Twiss interferometer. Classical and quantum coherence functions, first and second order coherence, coherent states. Discussion of Young's experiment in quantum mechanical terms. Introduction to Fourier optics and optical information processing.

3. Quantization of Analog signal, A/D & D/A conversion, Bit Rate, Pulse Code Modulation, NRZ, RZ and Manchester Coding, Base Line Wander Effect, Advantages of Optical Communication, Eye pattern Technique Time Division Multiplexing, Wave length Division Multiplexing WDM Devices, Multiplexers & De-Multiplexers.

4. Direct Detection and Coherent Heterodyne Detection concept of Optical frequency Division Multiplexing, NEP Heterodyne, Optical Amplifiers, Erbium Doped Fiber Amplifier, Semiconductor Optical Amplifier, Fiber Bragg Grating, System Design, Power Budget, Band width Budget and Rise Time Budget Calculations.

Reference Books:

- A.K. Ghatak and K. Thyagarajan, Optical Electronics (Cambridge University Press)
- J. M. Senior, Optical fiber Communications, Principles & Practice, (Prentice Hall of India).
- G. Kaiser, Optical fiber Communications, McGraw Hill Book Company.
- Ajoy Ghatak, K. Thyagarajan, Introduction to Fiber optics.
- N.S. Kapani, Fibre Optics (Academic Press, New York).
- Baa E. Saleh, Fundamentals of Photonics
- P. Hariharan, Optical holography, (Cambridge University Press, 1984).
- Fourier Optics by Joseph Goodman, Tata McGraw Hill

- Digital Electronics by Malvino

Course Learning Outcome:

1. Students will be able to learn the basics of holographic photography and holograms, holographic interferometry, optical data processing, Quantization of Analog signals, Multiplexing and the devices involved, system design and Rise time budget calculations.

PHD-504: NANOTECHNOLOGY

L	T	P	Cr
3	0	0	3

Course Objective:

1. To enable the students to understand the basic concepts of nanotechnology.
2. To understand the concepts of 1D, 2D and 3D confinement along with the density of states.
3. To acquaint the students with nanoscale systems, 1D, 2D and 3D systems.
4. To understand about the growth and synthesis of nanostructure materials by various deposition processes along with the growth mechanism models.

Course Content:

Physics of low-dimensional materials, 1D, 2D and 3D confinement, Density of states, Excitons, Coulomb blockade, Surface plasmon, Size and surface dependence of physical, electronic, optical, luminescence, thermo-dynamical, magnetic, catalysis, gas sensing and mechanical properties. Physical and chemical techniques for nanomaterial synthesis, Physical Vapor Deposition, Glow Discharge and Plasma, Sputtering–mechanisms and yield, Chemical Vapor Deposition, Chemical Techniques - Spray Pyrolysis, Electrodeposition, Sol-Gel, Nucleation & Growth: capillarity theory, atomistic and kinetic models of nucleation, basic modes of nanostructure growth, Growth mechanisms.

References:

1. The Physics of Low Dimesional Semiconductors: An Introduction by John H. Davies
2. Materials Science of Thin Films by Milton Ohring
3. Nanotechnology: Gregory L.Timp
4. Thin Film Phenomena by K.L. Chopra
5. F.C. Phillips: An introduction to crystallography (wiley)(3rd edition)

6. Introduction of Solids: L.V. Azaroff
7. Solid State Physics-Structure and Properties of Materials: M.A. Wahab
8. Solid State Physics: N.W. Ashcroft and N.D. Mermin
9. C. Kittel: Solid-state physics (Wiley eastern) (5th edition).

Course Learning Outcome:

After the successful completion of the course, the student will learn the following:

1. Concept of Quantum confinement, 1D,2D, and 3D nano systems with examples.
2. Different synthesis techniques including PVD and CVD systems along with the growth models.
3. Characterization of nanostructured materials using X-ray diffraction, electron microscopy, Atomic Force Microscopy and Scanning Tunneling Microscopy.
4. Physical, electronic, magnetic and optical properties of nanostructured materials.

PHD-505: ATOMISTIC MODELLING AND SIMULATIONS

L	T	P	Cr
3	0	0	3

Course Objective:

The objective of the course is to enable the students

1. To understand the mathematical concepts of molecular modeling.
2. To understand about empirical force fields models with examples.
3. To understand about Advanced *ab initio* methods and density functional theory.

Course Content:

Useful concepts of Molecular modeling: Mathematical concepts and review of related basics.

Empirical Force Field Models: Molecular Mechanics force fields, bond stretching, angle bending, Van der Waals interactions, pair potentials, Common and popular force field potentials.

An Introduction to the Computational Mechanics: One electron atom,

Advanced *ab initio* methods, Density Functional Theory: Open shell systems, Electron correlation, Valence bond theories, The Hartree-Fock equations, semi-empirical methods.

Energy minimization and related methods: Non-derivate minimization methods, Second derivative methods, Quasi Newton methods.

Simulations and molecular dynamics methods: (overview only) Calculating thermodynamic properties, Truncation of potentials, Long range potentials, Constraint dynamics, Time dependant properties, Monte Carlo methods.

References:

1. A. R. Leach, Molecular Dynamics.
2. R. M. Martin, Electronic Structure: Basic theory and practical methods.
3. J. Kohnoff, Electronic structure calculations for solids and molecules.
4. D. Frenkel, Understanding Molecular Dynamics.
5. J. M. Haile, Molecular Dynamics Simulations.
6. M. P Allen, Computer Simulations of Liquids.

Course Learning Outcome:

After the successful completion of the course, the student should be able,

1. To learn the mathematical concepts of molecular modeling.
2. To know about molecular mechanics force fields, bond stretching, angle bending, Van der Waals interactions, pair potentials.
3. To learn and apply *ab-initio*methods and density function theory to calculate the structural and other parameters of a system.
4. To learn the basic concepts of simulations and molecular dynamics methods to calculate the thermodynamic properties, potentials etc. for a particular system.

PHD-506: BIO PHYSICS

L	T	P	Cr
3	0	0	3

Course Objective:

The objective of the course is

1. To enable the students to relate application of physics to biological systems, from the first picture of the structure of DNA, to the treatment of cancer, and the understanding of allergic reactions.
2. To understand the concepts and techniques of biophysics find applications in bioelectronics, medicine/health, and population dynamics and are closely related to statistical mechanics and transport processes.

Course Content:

Introduction: The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic process and diversity of macroscopic form.

Living State Thermodynamics: Interaction in biology system, Structure of Biomolecules: and confirmations of protein and nucleic acids, Secondary, tertiary and quaternary structure of protein, Primary and secondary structure of RNA and DNA, Method of conformational analysis and prediction of conformation, Thermodynamics and kinetics of conformational transition of proteins, Protein folding, techniques for studying Macromolecular structure, Ultra centrifugation Sedimentation velocity and equilibrium determination of molecular weights.

Bioenergetics and Molecular motors: Kinesin and Dynein, microtubule dynamics, Brownian motion, ATP synthesis in Mitochondria, Photosynthesis in Chloroplasts, Light absorption in bio-molecules.

Mechanical properties of Biomaterials: Elastic Moduli, Electric stresses in Biological Membranes, Mechanical effects of microgravity during spaceflight.

Bio magnetism: Bio magnetic field Sources, nerve Impulses, magnetostatic bacteria, SQUID magnetometry.

Recent Topics in Bio-Nanophysics

References:

- Introductory Biophysics, J. Claycomb, JQP Tran, Jones & Bartelett Publishers
- Aspects of Biophysics, Hughe S W, John Willy and Sons.
- Essentials of Biophysics by P Narayanan, New Age International
- M.V. Volkenstein, General Biophysics, Academic Press

Course Learning Outcome:

On successful completion of the course students will be able to:

1. Explain models of biological systems and models dealing with statistical mechanics and transport phenomena.
2. Solve qualitative and quantitative problems, using appropriate statistical mechanics and computing techniques.
3. Understand the mechanical and magnetic properties of biomaterials with the concepts pf physics.

PHD-507: COMPUTATIONAL STRUCTURAL BIOLOGY

L	T	P	Cr
3	0	0	3

Course Objective:

The objective of the course is to

1. introduce computational algorithms and data processing strategies used in modern biophysics and structural biology.
2. To provide the basic idea on the structure and information of proteins.
3. To introduce the students with various molecular simulations methods.

Course Content

Introduction to experimental methods (X-ray and NMR) of protein structure determination, Basic ideas on structure and conformations of proteins, Structural motifs and analysis of information from protein databank, Homology modeling and protein structure prediction. Aspects of biomolecular forces, Introduction to various molecular simulations methods, Molecular dynamics (GROMACS, VMD and NAMD), Molecular docking (protein ligand docking).

References:

- Thomas E. Crieghton, Proteins: Structures and Molecular Properties
- Andrew Leach, Molecular Modeling: Principles and Applications
- Branden &Tooze, Introduction to Protein Structure
- Tamar Schlick, Molecular Modeling and Simulation: An Interdisciplinary Guide

Course Learning Outcome:

After rhe successful completion of the course, the students will be able to:

1. Characterize the role of structural biology in concurrent biomedical research.
2. Describe the functionality, advantages, and limitations of standard computing strategies used in processing of 3D structural data.
3. Acquire a working knowledge of freely available software and algorithms by learning the molecular simulation method.

PHE-501: RESEARCH METHODOLOGY

L	T	P
3	0	0

Course Objective:

1. To familiarize participants with basic of research and the research process and ethics in research.
2. To enable the studentsto choose right problem and methodology.
3. To explain the students about conducting research work and formulating research synopsis and report.

4. To familiarize participants national and international journals.
5. To impart knowledge about scientific writing.

Course Content:

Unit I: Introduction

Philosophy of research, Introduction to research methods, Relevance and ambiguity in applied research, Ethics in research, Scientific explanation and understanding in science, characteristics of scientific research and logic of scientific enquiry, Introduction to different perspectives and types of research.

Designing Research: Meaning, Elements and Need of research design, features of a good design, Different types of research design, developing a research plan, Defining the research problem and hypothesis, selecting a problem, Necessity of defining the problem, Techniques involved in defining a problem; Hypothesis – Types of hypotheses, Differences between hypothesis and research problem.

Priority Setting in Research: Introduction to setting research priorities - Process – Links with planning, participation, time and information, Steps – choosing the right problem, defining objectives and Options, Choosing and evaluating, preparing for implementation, Type of research, Choosing a Methodology, Methods of setting research priorities.

Unit II: Review of Published Research

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and Wiki-Databases, Academic databases and search engines: Science Direct, Sci Finder, Scopus, Web of knowledge. Finding and citing published information.

Unit III: Methods of Scientific Writing:

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism. Introduction to LaTeX.

Unit IV: Communicating Results for Application

Identifying users and their needs, Channels of communication with users, Type of research – user linkages, Management options for strengthening researcher-user communication; Communicating Scientific Results: Importance of research communication in science, Overview of research communication process in science, Role of scientific journals – quality of journals, citation index, other options for communicating results.

References:

- Research Methodology in Chemical Sciences: Experimental and Theoretical Approach Tanmoy Chakraborty, Lalita Ledwani, CRC Publishers.
- Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
- Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press. 4. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
- Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
- Date, C. J. An Introduction to Database System, Addision Wesley, U.K (1986).
- Caulcutt R, R Boddy, Statistics for Analytical Chemists, First Ed. 1983, By, Chapman & Hall.
- Medhi, J. Statistical Methods. Wiley Eastern, New Delhi (1992).

Course Learning Outcome:

After the successful completion of the course, the students are expected to

1. Develop understanding on various kinds of research, objectives of doing research, research process, research designs and sampling.
2. Understanding of research ethics.
3. Have basic knowledge on qualitative research techniques.
4. Ability to define problems and select the journals for publishing research work.

PHP-504: LAB – III

L	T	P	Cr
0	**0**	**6**	**6**

Course Objective:

1. To provide the practical knowledge of experimental electronics and optoelectronics.
2. Learn to acquire data in various experimental systems and to understand the use of various electronic systems.
3. To design a circuit on the bread-board for a particular experiment.
4. To keep the record of the experiments, performed in the laboratory.
5. To Interpret the results using the correct physical scientific framework and tools.

Course Content:

1. To verify the arithmetic and logic function of ALU.
2. To study the time period of (555 timer) astable 555 and monostable 555.

3. To determine the wavelength of laser using diffraction grating.
4. To determine the numerical aperture of optical fiber.
5. Dead time of a Geiger Muller (GM) Counter.
6. To calculate the e/m ratio using Milikan oil drop experiment.
7. To determine the magnetic susceptibility (diamagnetic or paramagnetic) of a given compound using Quincke's tube.
8. Melde's Experiment

Course Learning Outcome:

1. Students will be able to learn the various mathematical operations using Boolean functions using ALU.
2. The students will learn the designing of circuit using 555timer.
3. The students will understand the diffraction through grating, experimental determination of aperture of optical fiber.
4. Students will learn to operate a GM counter and relate it with the theory.
5. Students will relate the concept of magnetic susceptibility for paramagnetic and diamagnetic materials by performing the experiment and analyzing it.
6. The student will relate the concepts of longitudinal, transverse and standing waves using Melde's experiment.

SEMESTER IV

PHP-553 Project
Credits-15

Course Objective:

1. This course is focused to facilitate student to carry out extensive research and development project or technical project through problem and gap identification,
2. Development of methodology for problem solving, interpretation of findings, presentation of results and discussion of findings.
3. To expose the students to advances in the various research areas worldwide.

Course Learning Outcome:

1. Students will be able to gain in depth knowledge of the area of research.
2. Learn experimental synthesis of various materials for certain applications.
3. Learn various mathematical/ computational tools for theoretical studies.
4. Understand and learn the working of various characterization tools.
5. Analyze and critically evaluate different technical/research solutions
6. Students will learn to discuss present their research work in a systematic manner.
7. Identify the issues that must be addressed within the framework of the specific dissertation in order to take into consideration