Department of Physics

Vision

To impart state-of-the-art knowledge of physics to create competency and skills

Mission

The department of physics is committed to impart quality education both in theoretical as well as experimental physics with special emphasis on 'learning by doing' for socio-economic growth.

POST GRADUATE PROGRAMME

Programme Educational Objectives (PEOs)

The M.Sc program in Physics shall produce professionals:

1. To impart quality education in physics to students so as they become globally competitive physicist.
2. To make the students to accept the challenges in physics and can effectively disseminate the knowledge of physics to coming generations.
3. To create strong interest in physics so as students can further develop themselves through self-study.
4. To create a sense of ethical responsibilities among students as far as role of physics in society is concerned.

Programme Outcomes (POs)

M.Sc Physics students will keep the ability to:

1. Apply principles/laws of physics to solve the physical problems.
2. Identify/formulate the complex physics problems.
3. Design the solutions for physics problems.
4. Conduct experiments in physics and interpret the data.
5. Use the modern tools to learn the physics.
6. Take the responsibility for physics practice.
7. Demonstrate the physics knowledge for sustainable development.
8. Use ethical principles and norms of physics practice.
9. Function effectively as individual as well as in a team.
10. Communicate the physics effectively.
11. Demonstrate the knowledge in physics to manage the physics projects effectively.
12. Lifelong learning of physics.

C/BOS

DEPARTMENT OF PHYSICS
STUDY SCHEME OF M.Sc. (PHYSICS) PROGRAMME

SEMESTER-I: Aug. to Dec. (Including examination)

S.N.	Sub Code	Subject title	L	T	P	Credits
1.	PH-8101	MATHEMATICAL METHODS OF PHYSICS-I	4	1	0	5
2.	PH-8102	QUANTUM MECHANICS-I	4	1	0	5
3.	PH-8103	ELECTRONICS	4	1	0	5
4.	PH-8104	CLASSICAL MECHANICS	4	1	0	5
5.	PH-8151	PHYSICS LABORATORY-I (Electronics & Optics)	0	0	8	4
		TOTAL CREDITS	16	4	8	24

SEMESTER-II: Jan. to May (Including examination)

S.N.	Sub Code	Subject title	L	T	P	Credits
1.	PH-8201	CLASSICAL ELECTRODYNAMICS	4	1	0	5
2.	PH-8202	ATOMIC & MOLECULAR PHYSICS	4	1	0	5
3.	PH-8203	QUANTUM MECHANICS-II	4	1	0	5
4.	PH-8204	MATHEMATICAL METHODS OF PHYSICS-II	4	1	0	5
5.	PH-8251	COMPUTATIONAL PHYSICS LAB	0	0	8	4
		TOTAL CREDITS	16	4	8	24

SEMESTER-III: Aug. to Dec. (Including examination)

S.N.	Sub Code	Subject title	L	T	P	Credits
1.	PH-9101	CONDENSED MATTER PHYSICS-I	4	1	0	5
2.	PH-9102	PLASMA PHYSICS	4	1	0	5
3.	PH-9103	STATISTICAL PHYSICS	4	1	0	5
4.	PH-9104	NUCLEAR AND PARTICLE PHYSICS	4	1	0	5
5.	PH-9151	PHYSICS LABORATORY-II (Atomic & Nuclear Physics; and Microwaves)	0	0	8	4
		TOTAL CREDITS	16	4	8	24

SEMESTER-IV: Jan. to May (Including examination)

S.N.	Sub Code	Subject title	L	T	P	Credits
1.	PH-9201	CONDENSED MATTER PHYSICS-II	4	1	0	5
2.	PH-9202	LASER AND ITS APPLICATIONS	4	1	0	5
3.	PH-9203	DIGITAL ELECTRONICS	4	1	0	5
4.	PH-9204	RADIATION PHYSICS	4	1	0	5
5.	PH-9251 **OR** PH-9252	PHYSICS LABORATORY-III (Materials Science & Digital Electronics) **OR** Project Work* (*See rules of 'Project Wok' allotment in the course syllabi book)	0	0	8	4
		TOTAL CREDITS	16	4	8	24

Ram 11/06/18 Deepali 11/6/18 11.6.18 (K.S. Mann) 11/06/18 11/6/18

Jagwinder Singh 11/06/18

w.e.f. July, 2018

PH-8101 **Mathematical Methods of Physics-I** **LTPC/4105**

Course outcomes

After successful completion of the course, the students should be able to understand

CO1: basic knowledge of complex variables and its application for physics problems

CO2: the partial differential equations and their use in basic sciences

CO3: the delta and gamma functions and their applications

CO4: the special functions such as Bessel, Legendre, Hermite and Laguerre functions.

CO5: the knowledge of Fourier series and Laplace transformation.

CO/PO Mapping (S/M/W indicates strength of correlation)						S-Strong, M-Medium, W-Weak						
COs	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		S										
CO2	S											
CO3	M											
CO4		S										
CO5						S						

PH-8101 Mathematical Methods of Physics-I LTPC/4105

Course outcomes

After successful completion of the course, the students should be able to understand

CO1: basic knowledge of complex variables and its application for physics problems

CO2: the partial differential equations and their use in basic sciences

CO3: the delta and gamma functions and their applications

CO4: the special functions such as Bessel, Legendre, Hermite and Laguerre functions.

CO5: the knowledge of Fourier series and Laplace transformation.

CO/PO Mapping (S/M/W indicates strength of correlation)									S-Strong, M-Medium, W-Weak			
COs	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		S										
CO2	S											
CO3	M											
CO4		S										
CO5						S						

PH-8101 Mathematical Methods of Physics-I LTPC/4105

UNIT-I

Complex Variables: Cauchy-Riemann conditions, analycity, Cauchy-Goursat theorem, Cauchy's Integral formula, branch points and branch cuts, multivalued functions, Taylor and Laurent expansion, singularities and convergence, calculus of residues, evaluation of definite integrals. Dispersion relation. **10L**

Delta and Gamma Functions: Dirac delta function, Delta sequences for one dimensional function, properties of delta function, Gamma function, factorial notation and applications, Beta function. **10L**

Differential Equations: Partial differential equations of theoretical physics, boundary value, problems. Neumann & Dirichlet Boundary conditions, separation of variables, singular points, series solutions, second solution. **10L**

UNIT-II

Special Functions: functions of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions: generating function, recurrence relations and special properties, orthogonality, various definitions of Legendre polynomials. Associated Legendre functions: recurrence relations, parity and orthogonality, Hermite functions, Laguerre functions. **15L**

Fourier Series and Integral Transforms: Fourier series, Dirichlet conditions. General properties. Convolution and correlation, Advantages and applications, Gibbs phenomenon. Fourier transforms, Development of the Fourier integral, Inversion theorem, Fourier transforms of derivatives; Momentum representation.
Laplace transforms, Laplace transforms of derivatives, Properties of Laplace transform, Inverse Laplace transformation. Applications. **15L**

Theory: 60L

BOOKS :

1. Mathematical Methods for Physicists : G. Arfken and H.J. Weber (Academic Press, San Diego) 7th edition, 2012.
2. Mathematical Physics : P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004.
3. Mathematical Physics : A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi),1986.
4. Mathematical Methods in the Physical Sciences – M.L. Boas (Wiley, New York) 3rd edition, 2007.
5. Special Functions : E.D. Rainville (MacMillan, New York), 1960.
6. Mathematical Methods for Physics and Engineering : K.F.Riley, M.P.Hobson and S.J. Bence (Cambridge University Press, Cambridge) 3rd ed., 2006.
7. Mathematical methods for Physics and Engineering, K.F. Rilay, M.P. Hobson and S.J. Bence, Cambridge Unive. Press (1998).
8. Complex variables and applications, J.W. Brown, R.V. Churchill, 8th Ed., McGraw Hill (2009).
9. Introduction to Mathematical Physics, C. Harper, (PHI) 1978.

C/BOS

PH-8102: Quantum Mechanics-I LTPC/4105

Course Outcomes:

After successful completion of this course, the students should be able to

CO1: Understanding of Dirac vector space & basic quantum operators.

CO2: Study the time evolution of quantum states & operators.

CO3: Understanding the spin, orbital & total angular momentum algebra.

CO4: Understanding the time independent perturbation theory.

CO5: Find out the ground states of different systems using Variational method

Pre-requisites: Nil

CO/PO Mapping

(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes(POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			S									
CO2			S									
CO3	M									M		
CO4	S											
CO5		M										

PH-8102 **Quantum Mechanics-I** **LTPC/4105**

UNIT-I

Basic Formulation and Quantum Kinematics:
Stern-Gerlach experiment as a tool to introduce quantum ideas, analogy of two level quantum system with polarization states of light. Complex linear vector spaces, ket space bra space, Schwarz inequality, Orthonormal basis and inner product, operators and properties of operators. Eigenkets of an observable, eigen kets as base kets, matrix representations. Measurements of observable, compatible vs. incompatible observable, Simultaneous eigenvectors ,commutator and uncertainty relations. Change of basis and unitary transformations. Diagonalisation of operators. Position, momentum and translation, momentum as a generator of translations, canonical commutation relations. Wave functions as position representation of ket vectors. Momentum operator in position representation, momentum space wave function. **17L**

Quantum Dynamics:
Time evolution operator and Schrödinger equation, special role of the Hamiltonian operator, energy eigen kets, time dependence of expectation values, spin precession. Schrödinger vs. Heisenberg picture, unitary operators, state kets and observable in Schrödinger and Heisenberg pictures, Heisenberg equations of motion, Ehrenfest's theorem. Harmonic oscillator in matrix mechanics. **13L**

UNIT-II

Angular Momentum:
Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigenvalues and eigenvectors of L2 and Lz. Spin angular momentum, General angular momentum. Eigenvalues and eigenvectors of J2 and Jz. Representation of general angular momentum operator, Addition of angular momenta, C.G. coefficients. **17L**

Stationary State Approximate Methods:
Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator, hydrogen, helium atoms, etc., Hyperfine splitting. **13L**

Total: 60L

BOOKS:

1. Modern Quantum Mechanics : J.J. Sakurai (Addison Wesley, Reading).
2. Introduction to Quantum Mechanics: Davd J. Griffiths (Pearson Publications)
3. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi).
4. Quantum Physics : S. Gasiorowicz (Wiley, New York).
5. Quantum Mechanics : V.K. Thankappan (New Age, New Delhi).
6. Quantum Mechanics : J.L. Powell and B. Crasemann (Narosa, New Delhi).

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PH-8103 **Electronics** **LTPC/4105**

Course Outcomes:

After successful completion of the course, the students should be able to

CO1: understand the basic knowledge about various devices of electronics.

CO2: use appropriate methods to analyze the electronic circuits.

CO3: use an operational amplifier for required application.

CO4: explain the overall function of an electronic circuit.

CO5: explain the basics of electromagnetic wave based communication systems.

CO/PO Mapping S-strong, M-medium and W-weak indicate the strength of correlation												
COs	Programme outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	W	W	W		W			S		W	S
CO2	S	S	S	M	S		M	W		W		M
CO3	S	W	M	W	W	S	S	S	S	M	S	S
CO4	S	S	W		W	M			M	S	W	W
CO5	M	W	S	W			S	M			M	

PH-8103 **Electronics** **LTPC/4105**

UNIT-I

Semiconductor Devices: Drift and diffusion of carriers, Generation and recombination of charges, continuity equation. Direct and indirect semiconductors. PN junction, diode equation, barrier width and Capacitance of PN junctions, Varactor, switching diode, Metal-semiconductor junctions; Photodiodes. Light emitting diodes, Semiconductor laser. FET as switch and amplifier. MOSFET, Enhancement and depletion mode, UJT, UJT as relaxation oscillator. IMPATT diode, four layer pnpn devices - diode, SCR, SCS, PUT, diac, triac, Tunnel diode. **15L**

Circuit Analysis-I: Network, Lumped and distributed circuits, energy sources- dependent and independent; Revisiting the elementary properties of resistance, capacitor and inductor and their frequency response; complex impedance, phasor diagram, series, parallel and compound circuits; super-position, Thevenin's, Norton and maximum power transfer theorems for direct as well as for alternating voltages; Mesh and Node analysis both for dc and ac. First order piecewise linear circuit, Dynamic route, jump phenomenon and relaxation oscillator, triggering of bi-stable circuits. Admittance, impedance and hybrid matrices for two port networks and their cascade and parallel combinations. **15L**

UNIT-II

Circuit analysis-II: Basics of Laplace transform- step, ramp, impulse, sinusoidal, exponential, elementary operational transform, inverse transform, initial and final value theorem, convolution integral, basics of s-domain analysis, Relation between time and frequency domains, response functions, logarithms, decibels, Bode plot, Transfer function, Location of poles and zeros of response functions of passive systems, Sinusoidal response, Frequency response. Stability in S-domain and Routh-Hurwitz stability criteria. **10L**

Operational amplifiers: Introduction, basics of an amplifier, block diagram op-amp, characteristics of an ideal and practical op-amp, equivalent circuit, voltage transfer curve, slew rate, inverting, non-inverting, open loop and close loop gain, differential amplifiers, common mode rejection ratio, transfer characteristics, Comparator characteristics, Zero crossing and non-zero crossing detector, integrator and differentiator, Peak detector, Summing amplifier, Logarithmic and antilogarithmic amplifiers, Current to voltage and Voltage to current converter, Sample and hold circuits; inverting and non-inverting Schmitt triggers, square/rectangular, triangular and saw tooth wave generators, mono-stable and a-stable multi-vibrators. Principle of an oscillator–Phase shift oscillator, Wien bridge oscillator, Principle of phase locking, voltage controlled oscillator. **14L**

Filters: Introduction to passive filters- classification, first order RC low-pass filter, RC high pass filter, RLC series band-pass and band reject filters.

Introduction to active filters, First order low and high pass filters. Second order Sallen and Key configurations for low and high pass filters. **6L**

Total:60L

Books:

1. Semiconductor Devices Physics and Technology by S.M. Sze(Wiley).

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2. Applications of Laplace Transforms by Leonard R. Geis (Prentice Hall, New Jersey).
3. Linear and Nonlinear Circuits by Chua, Desoer and Kuh(Tata Mc Graw).
4. Integrated Electronics by Millman and Halkias(Tata Mc Graw Hill).
5. Electronic devices and Circuit theory by Boylestad and Nashelsky(Preutice Hill).
6. OPAMPS and Linear Integrateed circuits by Ramakant A Gayakwad(Preutice Hill).
7. Electronic Principles by A.P. Malvino(Tata Mc Graw Hill, New Delhi).

PH-8104 **Classical Mechanics** **LTPC/4105**

Course outcomes:

After successful completion of the course, the students should be able to

CO1: Explain the difference between Newtonian mechanics and analytical mechanics.

CO2: Be able to relate symmetries to conservation laws in physical systems, and apply these concepts to practical situations.

CO3: Demonstrate a working knowledge of classical mechanics and its application to standard problems such as central forces.

CO4: Solve dynamical problems involving classical particles by using the Lagrangian and Hamiltonian formulation.

CO5: Understand different aspects of motion of Rigid bodies, and their symmetry axes.

CO6: Be able to distinguish between stable and unstable equilibrium and understand physics of small oscillations.

CO7: Understand the concept of Canonical transformations and find out equations of motion using Poisson brackets.

CO/PO Mapping
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

Cos	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		M										
CO2	S											S
CO3	S											
CO4			S									
CO5							S					
CO6	S									S		
CO7			S									

PH-8104 Classical Mechanics LTPC/4105

UNIT-I

Lagrangian Formulation:
Comparison Newtonian mechanics and analytical mechanics (qualitative idea), Mechanics of a system of particles: constraints of motion, generalized coordinates, D'Alembert's Principle and Lagrange's velocity-dependent forces and the dissipation function, Applications of Lagrangian formulation. **10L**

Hamilton's Principles:
Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to non-holonomic systems advantages of variational principle formulation, symmetry properties of space and time and conservation theorems. **10L**

Hamilton's Equations:
Phase space concept, Legendre Transformation, Hamilton's equations of motion, Cyclic coordinates, Hamilton's equations from variational principle, Principle of least action. **10L**

UNIT-II

Rigid Body Motion:
Independent coordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top, central force problem. **14L**

Small Oscillations: Eigen value equation, Free vibrations, Normal Coordinates, Vibrations of a triatomic molecule. **5L**

Canonical Transformation and Hamilton Jacobi Theory:
Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton Jacobi equations for principal and characteristic functions Action angle variables for systems with one degree of freedom. **11L**

Total: 60L

BOOKS:
1. Classical Mechanics: H. Goldstein, C. Poole and J. Safko (Pearson Education Asia, New Delhi).
2. Analytical Mechanics: L.N. Hand and J.D. Finch (Cambridge University Press, Cambridge)
3. Mechanics: L.D. Landau and E.M. Lifshitz (Pergamon, Oxford).
4. Classical Mechanics of Particles and Rigid Bodies: K.C. Gupta (Wiley Eastern, New Delhi).
5. Classical Mechanics: N.C. Rana and P.J. Joag (Tata McGraw Hill, New Delhi).

C/BOS

PH-8151 Physics Laboratory-I *(Electronics and Optics)* LTPC/0084

Course Outcomes:
After successful completion of the course, the students should be able to

CO1: verify the theoretical formulations/ concepts of physics.

CO2: know the art of recording the observations of an experiment scientifically.

CO3: learn by doing.

CO4: handle and operate the various elements/parts of an experiment.

CO5: understand the importance of physics experiments in engineering & technology.

CO/PO Mapping
S-strong, M-medium and W-weak indicate the strength of correlation

COs	Programme outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2		S										
CO3				S								
CO4											M	
CO5							M					

PH-8151 Physics Laboratory-I *(Electronics and Optics)* LTPC/0084

List of Practical:

Electronics:

1. The application of operational amplifier:
   I. as integrator and differentiator
   II. inverting and non-inverting amplifier

2. To study:
   I. RC phase shift oscillator II. Wein bridge oscillator

3. To study the characteristics of SCR and TRIAC

4. To study the characteristics of UJT and MOSFET

5. To study the characteristics of Si diode, Ge diode, FSD diode, Zener diode, light emitting diode and varactor diode.

Optics:

6. To determine the wavelength of He-Ne laser by:
   a) using diffraction method
   b) using Michelson-Morley interferometer

7. To setup polarization by reflection and:
   a) to determine Brewster's angle for glass surface
   b) to verify Malus law

8. Based upon Faraday's effect using flint glass square to determine Verdet's constant and also to verify the relationship between Verdet's constant and wavelength of light used.

9. To setup optical fiber kit and to:
   a) study optical coupling
   b) determine the NA of fiber
   c) determine the transmission loss coefficient by the cut-back method
   d) implement the experiment of optical fiber for pressure sensing.

10. To setup experiment for 'Acousto-optic effect' and to
    a) calculate the diffraction efficiency of acousto-optic device
    b) calculate the Bragg angle
    c) calculate the velocity of sound in acousto-optic medium
    d) demonstrate optical communication using acousto-optic modulation

11. To construct/assemble:
    a) Michelson interferometer and measuring the refractive index of air
    b) Sagnac interferometer

c) 1305

c) Mach-Zehnder interferometer

12. To setup the holography kit and to
    a) record and reconstruct the hologram
    b) make the holographic grating

13. To study the different modes of He-Ne laser with an oscilloscope by using He-Ne laser mode analyzer.

14. To set up the Laser Raman Spectrometer and to acquire the Carbon Tetra Chloride (CCl_4) spectrum.

15. To set the Fourier optics apparatus and to study optical image
    a) addition and subtraction
    b) differentiation

16. a) Fraunhofer diffraction of a single circular aperture and single slit
    b) Fresnel diffraction of a single slit and sharp edge.
17. Assembling telescopes forming an inverted image and erect image

Practical: 96 Hrs **Total: 96 Hrs**

PH-8201 **Classical Electrodynamics** **LTPC/4105**

Course outcomes:

After successful completion of the course, the students should be able to

CO1: Understanding and using (skill of solving problems, calculating) electrostatics and magnetostatics, in vaccum, in the presence of conductors and linear dielectrics by using methods of electrodynamics.

CO2: Elaborate on the physical implications of Maxwell's equations

CO3: Do multipole expansions of electrostatic and magnetostatic fields

CO4: Explain and use conservation laws for energy, Poyinting vector, Momentum, Maxwell stress tensor.

CO5: Understanding and using (skill of solving problems, calculating) electrodynamics in media, macroscopic fields, susceptibilities, dielectrics and conductors, boundary conditions, radiation.

CO6: Understanding and using (skill of solving problems, calculating) retarded potentials and gauge transformations.

CO7: Analyze propagation, reflection and transmission of plane waves at interface and through wave guides

CO8: Understanding (basic) theory of relativity and its connection to electrodynamics, calculating elementary problems in relativistic mechanics and electrodynamics.

CO/PO Mapping (S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak												
COs	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											S
CO2												
CO3												
CO4			M									
CO5		S										
CO6												
CO7												
CO8												

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PH-8201 **Classical Electrodynamics** **LTPC/4105**

UNIT-I

Electrostatics in Vaccum: Coulomb's law, Gauss law, scalar potential, Laplace and Poisson's equations, Electrostatic potential and energy density of the electromagnetic field. **5L**

Electrostatics in Dielectrics: Static fields in material media, Polarization vector, macroscopic equations, classification of dielectric media, Molecular polarizability and electrical susceptibility, Clausius-Mossetti relation, Models of Molecular polarizability, energy of charges in dielectric media. **5L**

Magnetostatics: The differential equations of magnetostatics, vector potential, magnetic fields of a localized current distribution, Singularity in dipole field, Force and torque on a localized current distribution. **5L**

Boundary Value Problems: Uniqueness theorems, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green's (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Methods of images with examples, magnetostatic boundary value problems (derivation of equation for H and M, some special cases, energy in the magnetic field). **10L**

Multipole Expansion: Multipole expansion of the scalar potential of a charge distribution, dipole moment, quadrupole moment, Multipole expansion of the energy of a charge distribution in an external field. **5L**

UNIT-II

Time Varying fields and Maxwell equations:
Faraday's law of induction, displacement current, Maxwell equations, scalar and vector potential, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, General expression for the electromagnetic fields energy, conservation of energy, Poynting Theorem, Conservation of momentum. **10L**

Electromagnetic Waves:
Wave equation, plane waves in free space and isotropic dielectrics, polarization, energy transmitted by a plane wave, Poynting theorem for a complex vector field, waves in conducting media, skin depth, Reflection and refraction of e.m. waves at plane interface, Fresnel's amplitude relations, Reflection and Transmission coefficients, polarization by reflection, Brewster's angle, Total internal reflection, Stoke's parameters, EM wave guides, Cavity resonators, Dielectric waveguide, optical fibre waveguide. **10L**

Radiation from Localized Time varying sources:
Solution of the inhomogeneous wave equation in the absence of boundaries, Fields and radiation of a localized oscillating source, electric dipole and electric quadrupole fields, centre fed antenna. **5L**

Charged Particle Dynamics: Non-relativistic motion in uniform constant fields and in a slowly varying magnetic field, adiabatic invariance of flux through an orbit, magnetic mirroring, Cross electrostatic and magnetic fields and applications, Relativistic motion of a charged particle. **5L**

Total: 60L

BOOKS:

1. Introduction to Electrodynamics: D.J. Griffiths, (Prentice Hall India, New Delhi).
2. Classical Electrodynamics: J.D. Jackson, (Wiley Eastern, New Delhi).

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3. Classical Electrodynamics: S.P. Puri (Tata McGraw Hill, New Delhi).
4. Classical Electromagnetic Radiation: J.B. Marion and M.A. Heald, (Academic Press, San Diego).
5. Foundations for Microwave Engineering: RE Collin (McGraw-Hill, New York)

PH-8202 **Atomic & Molecular Physics** **LTPC/4105**

Course Outcomes:

After successful completion of the course, the students should be able to

CO1: Understand the basic principles of electronic transitions, emission and absorption spectra

CO2: Understand the atomic structure, how atoms in molecules are related to each other and influence of external fields on spectra

CO3: Understand the vibration and rotational spectroscopy of diatomic molecules

CO4: Compare and contrast atomic and molecular spectra

CO5: Describe the meaning and consequences of absorption and emission spectroscopy

CO/PO Mapping
S- strong, M-medium and W-weak indicate the strength of correlation

COs	Programme outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2	S											
CO3	S		M									
CO4										M		
CO5	S							M				

C/BOS

PH-8202

Atomic & Molecular Physics LTPC/4105

UNIT-I

Spectra of one and two valance electron systems:
Magnetic dipole moments; Larmor's theorem; Space quantization of orbital, spin and total angular momenta; Vector model for one and two valance electron atoms; Spin-orbit interaction and fine structure of hydrogen, Lamb shift, Spectroscopic terminology; Spectroscopic notations for L-S and J-J couplings; Spectra of alkali and alkaline earth metals; Interaction energy in L-S and J-J coupling for two electron systems; Selection and Intensity rules for doublets and triplets. **15L**

Breadth of spectral line and effects of external fields: The Doppler effect; Natural breadth from classical theory; natural breadth and quantum mechanics; External effects like collision damping, asymmetry and pressure shift and stark broadening; The Zeeman Effect for two electron systems; Intensity rules for the Zeeman effect; The calculations of Zeeman patterns; Paschen-Back effect; LS coupling and Paschen–Back effect; Lande's factor in LS coupling; Stark effect. **15L**

UNIT-II

Microwave and Infra-Red Spectroscopy:
Types of molecules, Rotational spectra of diatomic molecules as a rigid and non-rigid rotator. Intensity of rotational lines, Effect of isotopic substitution, Microwave spectrum of polyatomic molecules, Microwave oven, The vibrating diatomic molecule as a simple harmonic and anharmonic oscillator, Diatomic vibrating rotator, The vibration-rotation spectrum of carbon monoxide, The interaction of rotation and vibrations, Outline of technique and instrumentation, Fourier transform spectroscopy. **15L**

Raman and Electronic Spectroscopy:
Quantum and classical theories of Raman Effect, Pure rotational Raman spectra for linear and polyatomic molecules, Vibrarional Raman spectra, Structure determination from Raman and infra-red spectroscopy, Electronic structure of diatomic molecule, Electronic spectra of diatomic molecules, Born Oppenheimer approximation-The Franck-Condon principle, Dissociation and pre-dissociation energy, The Fortrat diagram, example of spectrum of molecular hydrogen. **15L**

Total: 60L

BOOKS:

1. Fundamentals of Molecular Spectroscopy: Colin N. Banwell and Elaine M. McCash- 4th Edition: Tata McGraw Hill, 1986.
2. Introduction to Atomic Spectra: H.E. White-Auckland Mc Graw Hill, 1934
3. Modern Spectroscopy: J.M. Hollas- 4th edition- 2004
4. Atomic and Molecular Spectroscopy by S. Svanberg, Springer Verlag
5. Spectroscopy Vol. I, II & III: Walker & Straughen
6. Introduction to Molecular Spectroscopy: G.M.Barrow-Tokyo Mc Graw Hill, 1962.
7. Spectra of Diatomic Molecules: Herzberg-New York, 1944.
8. Molecular Spectroscopy: Jeanne L McHale-New Jersy Prentice Hall, 1999.
9. Molecular Spectroscopy: J.M. Brown-Oxford University Press, 1998.
10. Spectra of Atoms and Molecules: P.F. Bermath-New York, Oxford University Press, 1995.

c/BOS

w.e.f. July, 2018

PH-8203 **Quantum Mechanics-II** **LTPC/4105**

Course Outcomes:

After successful completion of this course, the students should be able to

CO1: Study the Time dependent perturbation Theory and its applications.

CO2: Study the selection rules for transitions between different quantum states.

CO3: Calculation of scattering cross-sectional area using Born-approximation & partial wave analysis method.

CO4: Study of Relativistic Quantum Mechanics.

CO5: Study of identical particles from Quantum mechanical point of view.

Pre-requisites: Quantum Physics-I

CO/PO Mapping
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes(POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		S										
CO2			M									
CO3		S										
CO4	M											
CO5	M											

w.e.f. July, 2018

PH-8203: Quantum Mechanics-II LTPC/4105

UNIT-I

Time Dependent Perturbation:
First order time dependent perturbation theory, General expression for the probability of transition from one state to another, constant and harmonic perturbations, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light. The Helium atom problem. Stark effect. **15L**

Scattering theory:
Scattering Cross-section and scattering amplitude, partial wave analysis, Low energy scattering, Green's functions in scattering theory, Born approximation and its application to Yukawa potential and other simple potentials and extend to higher orders. Validity of Born approximation for a square well potential. Optical theorem. unitarity and phase shifts. Determination of phase shift, applications to hard sphere scattering. Low energy scattering in case of bound states. Resonance scattering. Scattering of identical particles. **15L**

UNIT-II

Relativistic Quantum Mechanics:
Klein Gordon equation. Dirac Equation, Lorentz covariance of Dirac equation. Positive and negative energy solutions of Dirac equation, positrons. Properties of gamma matrices. Parity operator and its action on states. Magnetic moments and spin orbit energy. **15L**

Identical Particles:
Brief introduction to identical particles in quantum mechanics (based on Feynmann Vol. III) symmetrisation postulates. Application to 2-electron systems. Pauli exclusion principle. Bose Einstein and Fermi Dirac Statistics. **15L**

Total: 60L

BOOKS:

1. Modern Quantum Mechanics by J. J. Sakurai (Principal text)-Pearson Education Pvt. Ltd., New Delhi, 2002.
2. Quantum Mechanics by L I Schiff-Tokyo Mc Graw Hill, 1968.
3. Feynman lectures in Physics Vol. III-Addison Wesly, 1975.
4. Quantum Mechanics by Powel and Craseman-Narosa Publication, New Delhi, 1961
5. Quantum Mechanics by Merzbacher-John Wiley & Sons, New York, 1970.

C/BoS

w.e.f. July, 2018

PH-8204 Mathematical Methods of Physics-II LTPC/4105

Course outcomes:

After successful completion of the course, the students should be able to

CO1: use the group theory as well as tensors in physics problems.

CO2: know the importance of integral equations in physics.

CO3: know the basic syntaxes of C++ computer language.

CO4: handle the programming in C++ computer language.

CO5: design themselves computer programs as per their need.

CO/PO Mapping (S/M/W indicates strength of correlation)									S-Strong, M-Medium, W-Weak			
COs	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		S										
CO2		S										
CO3					S							
CO4			S									
CO5								S				

PH-8204 Mathematical Methods of Physics-II LTPC/4105

UNIT-I

Group Theory : What is a group? Multiplication table, conjugate elements and classes, subgroups, Isomorphism and Homomorphism, Definition of representation and its properties, Reducible and irreducible representations, Schur's lemmas (only statements), characters of a representation. Example of C4v, Topological groups and Lie groups, three dimensional rotation group, special unitary groups SU(2) and SU(3). **12L**

Tensors : Tensors in index notation, Kronecker and Levi Civita tensors, inner and outer products, contraction, symmetric and antisymmetric tensors, quotient law, Noncartesian tensors, metric tensors, covariant and contravariant tensors, Covariant differentiation. Applications. **10L**

Integral Equations : Definitions and classifications, integral transforms and generating functions. Neumann series, Separable Kernels, Hilbert-Schmidt theory. Green's functions in one dimension. **8L**

UNIT-II

Computational physics and data analysis: Introduction to C++, classes, objects, C++ programming syntex for input and output, loops, decisions, simple and inline functions, strings and pointers. **10L**

Programs (C++ using "Classes") based on the basic numerical methods:
Statistics : Measures of central moment, correlation coefficients. Interpolations - Least squares fitting, Lagrange interpolation, Cubic spline fitting. Numerical differentiation, Numerical integration by Simpson and Weddle's rules; Numerical solution of differential equations by Euler, predictor-corrector and Runge-Kutta methods, problems. Matrices, addition, multiplication, determinant, eigenvalues and eigenvectors, inversion, solution of simultaneous equations. **20L**

Total: 60L

Books :

1. Group Theory for Physicists : A.W. Joshi (Wiley Eastern, New Delhi) 2011.
2. Mathematical Methods for Physicists : G. Arfken and H.J. Weber, (Academic Press, San Diego) 7th edition, 2012.
3. Matrices and Tensors in Physics : A.W. Joshi (Wiley Eastern, New Delhi) 2005.
4. Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co., Kolkata) 4th edition.
5. A First Course in Computational Physics: P.L. Devries (Wiley, New York) 1994.
6. Mathematical Physics : P.K. Chatopadhyay (Wiley Eastern, New Delhi) 2011.
7. Introduction to Mathematical Physics : C. Harper (Prentice Hall of India, New Delhi) 2006.
8. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
9. A first course in Computational Physics: P.L. DeVries (Wiley) 2nd edition, 2011.
10. Computer Applications in Physics: S. Chandra (Narosa) 2nd edition, 2005.
11. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
12. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 4th edition 2008.

C/BOS

w.e.f. July, 2018

PH-8251 COMPUTATIONAL PHYSICS LAB LTPC/0084

Course outcomes

After successful completion of the course, the students should be able to

CO1: To have knowledge of programming techniques especially in C++

CO2: To have knowledge of Data types, Operators and expressions

CO3: To know how to handle data files

CO4: familiarity with special methods such as Simpson's 1/3[rd] , Euler's, Rugne-Kutta method

CO5: applying learned programming to typical physics problems.

CO/PO Mapping
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2								S				
CO3					S							
CO4		S										
CO5											S	

PH-8251 **COMPUTATIONAL PHYSICS LAB** **LTPC/0084**

Programming with C++

List of general programs

Write a program to

1. find the nature of the roots as well as value of the roots.
2. add two matrices.
3. multiply matrix
4. sort a list of n integer numbers in descending order
5. find the solution of non-linear equation using Bisection method.
6. find the solution of non-linear equation using Newton's method.
7. fit a straight line of type $y = ax + b$ through a given set of data points.
8. find the numerical integration of a function using Trapeziodal rule.
9. find the numerical integration of a function using Simpson's 1/3rd rule.
10. find the numerical solution of ordinary differential equations using Euler's method.
11. find the numerical solution of ordinary differential equations using 4rth order Rugne-Kutta method.
12. find the solution of system of linear equations using Gauss-Seidel method.

List of Physics Problems

1. Write a program to study graphically the EM oscillations in a LCR circuit (use Runge-Kutta Method). Show the variation of (i) Charge vs Time and (ii) Current vs Time.
2. Study graphically the motion of falling spherical body under various effects of medium (viscous drag, buoyancy and air drag) using Euler method.
3. Study graphically the path of a projectile with and without air drag using FN method. Find the horizontal and maximum height in either case. Write your comments on the findings.
4. Study the motion of an artificial satellite.
5. Study the motion of
   (a) 1-D harmonic oscillator (without and with damping effects).
   (b) two coupled harmonic oscillators. Draw graphs showing the relations:
   I. Velocity vs Time II. Acceleration vs Time III. Position vs Time, also compare the numerical and analytical results.
6. To obtain the energy eigenvalues of a quantum oscillator using the Runge-Kutta method.
7. Study the motion of a charged particle in: (a) Uniform electric field, (b) Uniform Magnetic field, (c) in combined uniform electric and magnetic fields. Draw graphs in each case.
8. Use Monte Carlo techniques to simulate phenomenon of
   (i) Nuclear Radioactivity. Do the cases in which the daughter nuclei are also unstable with half life greater/lesser than the parent nucleus.
   (ii) to determine solid angle in a given geometry.
   (iii) simulate attenuation of gamma rays/neutron in an absorber and
   (iv) solve multiple integrals and compare results with Simpson's method.
9. To study phase trajectory of a Chaotic Pendulum.
10. To study convection in fluids using Lorenz system.

C/BOS

BOOKS

1. Numerical Recipes in C++ The Art of Scientific Computing, William H. Press, Saul A. Teukolsky, William T. Vetterling and Brian P. Flannery, (Cambridge), 2nd ed. 2002.
2. A First Course in Computational Physics: P.L. DeVries (John Wiley) 2000.
3. An introduction to Computational Physics: Tao Pang (Cambridge), 2nd ed. 2006.
4. Computer Applications in Physics: S. Chandra (Narosa), 2006.
5. Computational Physics: R.C. Verma, P.K.Ahluwalia and K.C. Sharma (New Age), 2005.
6. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill), 5th ed. 2011.

Total: 96Hrs

C/BOS
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PH-9101 Condensed Matter Physics-I LTPC/4105

Course Outcomes:

After successful completion of the course, the students should be able to

CO1: Explain the significance and value of condensed matter physics, both scientifically and in the wider community

CO2: Operate with crystal lattices, symmetries and in point groups both in real space and in the reciprocal space (momentum space) and describe diffraction using the reciprocal lattice.

CO3: Use models to calculate dispersion relations and able to find the thermal properties of solids.

CO4: To describe and explain the properties associated with dielectric and ferroelectric materials.

CO5: To describe and explain different kinds of magnetism and related the phenomena.

CO6: Understand the phenomenon of superconductivity and their properties in order to their applications.

CO/PO Mapping

S-strong, M-medium and W-weak indicate the strength of correlation

COs	Programme outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							S	S	S	S		
CO2					M						M	S
CO3	S		S	M								
CO4	S	M			S	S						
CO5	S				S	S						M
CO6	S		S	S	S		S			S		M

PH-9101 **Condensed Matter Physics-I** **LTPC/4105**

UNIT I

Crystal Physics, Reciprocal Lattice and X-ray diffraction: Crystal solids, unit cells and space lattice, Bravais lattices, Crystal structures-sc; bcc ; fcc ; hcp, NaCl, ZnS and diamond structure, crystal planes and Miller indices, Inter planar spacing, Atomic packing factor, close packed structures, symmetry elements in crystals, point groups and space groups.
Reciprocal lattices and its applications to diffraction techniques, Brillouin zones, Diffraction of X-rays by lattice, the Laue equation, Bragg 's law, Ewald construction, experimental diffraction techniques- powder X-ray diffraction technique, indexing of powder photographs and lattice parameter determination, applications of powder method, general concept of atomic scattering factor and crystal structure factor. **20L**

Lattice Dynamics and thermal properties: Lattice waves, Vibrations of one –dimensional mono and diatomic lattice, Phonon dispersion, phonon momentum, density of normal modes in one and three dimensions, quantization of lattice vibrations, Einstein and Debye's model of specific heat, Thermal expansion, Thermal conductivity. **10L**

UNIT II

Dielectric and Ferroelectric Properties: The Dielectric constant and polarizability, Clausius- Mossotti relation, Measurement of dielectric constant, Dipolar polarization in solids, Ionic polarizability, electronic polarizability, Ferroelectricity, Ferroelectric domain. **13L**

Magnetic and Superconducting properties: Fundamental concepts, quantum theory of diamagnetism and paramagnetism, Weiss Theory of Ferromagnetism, Curie-Weiss law for susceptibility. Ferri and Anti Ferro-magnetic order. Anisotropic energy. Occurrence of supercunductivity. Meissner effect, Type-I and Type-II superconductors, Heat capacity, Energy gap, Isotope effect, London equation, Coherence length, Postulates of BCS theory of superconductivity, flux quantization, Josephson effect, High temperature oxide super conductors. **17L**

Total: 60L

BOOKS:

1. Introduction to Solids by L.V. Azaroff
2. Crystallography for Solid State Physics by Verma and Srivastava
3. Solid State Physics by C. Kittel
4. Solid State Physics by M.A. Wahab
5. Elementary Solid State Physics by M. A. Omar
6. Crystal Structure Determination by G.H. Stout, L.H. Jensen
7. The Solid state by H.M. Rosenber

C/BOS

PH-9102 Plasma Physics LTPC/4105

Course outcomes:

After successful completion of the course, the students should be able to

CO1: Define plasma state, give examples of different kinds of plasma and explain the parameters characterizing them

CO2: Analyze the motion of charged particles in electric and magnetic fields

CO3: Determine the velocities, both fast and slow (drift velocities), of charged particles moving in electric and magnetic fields that are either uniform or vary slowly in space and time.

CO4: Classify the electrostatic and electromagnetic waves that can propagate in magnetized and non-magnetized plasmas, and describe the physical mechanisms generating these waves.

CO5: Define and determine the basic transport phenomena such as plasma resistivity, diffusion (classical and anomalous) and mobility as a function of collision frequency and of the fundamental parameters for both magnetized and non-magnetized plasmas.

CO6: Explain the concept of plasma instability, and analyze the instabilities based on the dispersion relation

CO7: Discuss interaction between particles and waves, Landau damping

CO8: Explain the use of thermonuclear fusion for energy production, and discuss plasma confinement.

CO/PO Mapping
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3	M											
CO4			M									
CO5		S										
CO6												
CO7												
CO8							M					M

PH-9102 Plasma Physics LTPC/4105

UNIT-I

Basics of Plasmas: Occurrence of plasma in nature, definition of plasma, concept of temperature, Debye shielding and plasma parameters, single particle motions in uniform E and B, nonuniform magnetic field, grad B and curvature drifts, invariance of magnetic moment and magnetic mirror. Simple applications of plasma. **10L**

Plasma Waves: Plasma oscillations, electron plasma waves, ion waves, electrostatic electron and ion oscillations perpendicular to magnetic field, upper hybrid waves, lower hybrid waves, ion cyclotron waves. Light waves in plasma. **10L**

Plasma Diagnostics Techniques: Single probe method, Double probe method, Use of probe technique for measurement of plasma parameters, Microwave method, Spectroscopic method, Laser as a tool for plasma diagnostics, X-ray diagnostics, Acoustic method. **10L**

UNIT-II

Boltzmann and Vlasov Equations: The Fokker Planck equation, integral expression for collision term, zeroth and first order moments, the single equation relaxation model for collision term. Applications of kinetic theory to electron plasma waves, the physics of Landau damping, elementary magnetic and inertial fusion concepts. **10L**

Non-linear Plasma Theories: Non-linear Electrostatic Waves, The Korteweg-de-Vries (KdV) equation, Nonlinear Schrodinger Equation, Solitons, Shocks, Non-linear Landau Damping. Non-linear Effects: Introduction, SHEATHS, ion acoustic shock waves, Ponderomotive force, Parametric Instabilities. **10L**

Plasma Applications: Source of power (MHD generator and Controlled thermonuclear fusion), Generation of microwaves utilizing high density plasma, plasma propulsion, materials processing with plasma arcs, plasma processing and fabrication (ion implantation in solids, plasma deposition and etching, paint spraying), Plasma chemistry and Pollution control (thermal, non-thermal, electrostatic precipitation, corona). **10L**

Total: 60L

BOOKS:

1. Introduction to Plasma Physics and Controlled Fusion: F F Chen-Springer, 1984
2. Fundamental of Plasma Physics: S R Seshadri-American Elsevier Pub. Co. 1973.
3. Industrial Plasma Engineering: J. R. Roth, IOP Publishing, Ltd 1995.
4. Plasma Physics: S.N.Sen, Pragati Prakashan, Meerut, second edition, 1996.
5. Glow Discharge Processes: Brian Chapman, John Wiley & Sons, 1980.

C/BoS

PH-9103 **Statistical Physics** **LTPC/4105**

Course Outcomes:

After successful completion of the course, the students should be able to

CO1: Learn fundamental principle of individual particles and their interactions as microscopic and macroscopic phenomenon

CO2: Learn thermodynamic equilibrium conditions for isolated, closed as well as open systems

CO3: Build systematic foundation to handle interacting systems in new problem areas of classical and quantum nature

CO4: Calculate and manipulate partition functions and to derive thermodynamic state functions analytically in some specific cases

CO5: Learn to solve problems with non-interacting fermions, bosons and quasi-particles

CO/PO Mapping
S- strong, M-medium and W-weak indicate the strength of correlation

COs	Programme outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2	S											
CO3	S		M									
CO4	S	M										
CO5	S		M									

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w.e.f. July, 2018

PH-9103 **Statistical Physics** **LTPC/4105**

UNIT-I

Classical Statistical Mechanics-I: Foundations of statistical mechanics; specification of states in a system; contact between statistics and thermodynamics; the classical ideal state; the entropy of mixing and Gibbs paradox; The phase space of a classical system; Liouville's theorem and its consequences.

12L

Classical Statistical Mechanics-II: The micro-canonical ensemble with examples; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations in the canonical ensemble; A system of harmonic oscillators; The statistics of Para-magnetism; The grand canonical ensemble; the physical significance of the statistical quantities with examples, fluctuations of energy and density, Cluster expansion of classical gas, the virial equation of state.

18L

UNIT-II

Quantum Statistical Mechanics I: Quantum states and phase space; the density matrix; statistics of various ensembles; Example of electrons in a magnetic field; a free particle in a box and a linear harmonic oscillator; Significance of Boltzmann formula in classical and quantum statistical mechanics.

12L

Quantum Statistical Mechanics II: An ideal gas in quantum mechanical micro-canonical ensemble; Statistics of occupation numbers, concepts and thermodynamical behaviour of an ideal gas; Bose-Einstein condensation, Discussion of a gas of photons and phonons; Thermodynamical behavior of an ideal Fermi gas, electron gas in metals, Pauli's Para magnetism; statistical equilibrium of white dwarf stars.

18L

Total: 60L

BOOKS:

1. Statistical Mechanics: R.K. Pathria: Butterworth-Heinemann-1996
2. Statistical Mechanics: Kerson Huang: Wiley-1963.

c/BoS

PH-9104 NUCLEAR AND PARTICLE PHYSICS LTPC/4105

Course outcomes

After successful completion of this course on Nuclear and particle Physics, the students should be able to understand:

CO1: The present description of matter and the mysteries of the fundamental interactions of matter.

CO2: The aspects of nucleon – nucleon interaction, nuclear forces and nuclear reactions.

CO3: The details of the nuclear models (Liquid drop model, shell model and the collective model)

CO4: The quantum mechanical descriptions of the models for beta and gamma nuclear decays; Neutrino decay, multipole transitions in nuclei and selection rules .

CO5: The details of interactions, conservation laws, quantum numbers and symmetries amongst the elementary particles.

CO6: The main aspects of the standard model of particle Physics

CO/PO Mapping
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2		S										
CO3			S									
CO4					M							
CO5						M						
CO6												S

C/BoS

PH-9104 NUCLEAR AND PARTICLE PHYSICS LTPC/4105

UNIT-I

Nuclear Interactions and Nuclear Reactions: Nucleon-nucleon interaction, Exchange forces-Meson theory of nuclear forces, Nucleon-nucleon scattering, effective range theory, spin dependence of nuclear forces, Charge independence and charge symmetry of nuclear forces, Isospin formalism, Yukawa interaction. Direct and compound nuclear reaction mechanisms, Cross sections in terms of partial wave amplitudes-Compound nucleus Scattering matrix, Reciprocity theorem, Breit-Wigner one-level formula, resonance scattering. **15L**

Nuclear Models: Liquid drop model, Bohr-Wheeler theory of fission, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic numbers, Angular momenta and parities of nuclear ground states, Quantitative discussion and estimates of transition rates, magnetic moments and Schmidt lines, Collective model of Bohr and Mottelson. **15L**

UNIT-II

Nuclear Decay: Beta decay, Fermi theory of beta decay, shape of the beta spectrum, Total decay rate, Angular momentum and parity selection rules, Comparative half-lives, Allowed and forbidden transitions-selection rules, parity violation, Two component theory of Neutrino decay, Detection and properties of neutrino, Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules, Internal conversion, Nuclear isomerism. **15L**

Elementary Particle Physics: Types of interaction between elementary particles, Hadrons and leptons, Symmetry and conservation laws, Elementary ideas of CP and CPT invariance, Classification of hadrons, Lie algebra, SU (2) multiples, Quark model, Gell Mann-Okubo mass formula for octel and decuplet hadrons, Charm, bottom and top quarks. **15L**

Total: 60L

BOOKS:

1. Introduction to Nuclear and Particle Physics by A Das and T Ferbel, World Scientific
2. Nuclear and particle Physics: An Introduction, by Brian Martin, Wiley
3. Nuclear and particle Physics by R.J. Blim Stoyle, CHAPMAN &v HALL
4. Nuclei and particles by E Segre, Benjamin, New York
5. Introductory Nuclear Physics, Kenneth S. Krane, Wiley
6. Introduction to high Energy Physics, P.H. Perkins, Addision-Wesley, London, 1982
7. Introduction to Elementary Particles, D. Griffiths, Harper and Row, New York, 1987.

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Secretary

PH-9151 Physics Lab-II *(Atomic & Nuclear Physics and Microwaves)* *LTPC/0084*

Course Outcomes:

After successful completion of the course, the students should be able to

CO1: Verify the theoretical formulations/ concepts of physics.

CO2: Know the art of recording the observations of an experiment scientifically.

CO3: Learn by doing.

CO4: Handle and operate the various elements/parts of an experiment.

CO5: Understand the importance of physics experiments in engineering & technology.

CO/PO Mapping S-strong, M-medium and W-weak indicate the strength of correlation												
COs	Programme outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2		S										
CO3				S								
CO4											M	
CO5							M					

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PH-9151 Physics Lab-II *(Atomic & Nuclear Physics and Microwaves)* *LTPC/0084*

List of Practical:

Atomic and nuclear Physics:

1. Study of photoelectric effect using photocell:
   a) To plot the current-voltage characteristics of a given photocell at constant irradiance
   b) To measure the photo-current as a function of irradiance at a constant voltage.
   c) To determine Planck's constant
   d) to verify the inverse square law

2. To determine the e/m ratio by
   (a) Millikon's oil drop method
   (b) Zeeman splitting of the green mercury line using Fabry-Perot etalon.

3. To setup ESR spectrometer and to determine the g-factor of electron using sample of DPPH.

4. To investigate the nuclear spin resonance in Glycerine, Polystyrene and Teflon with NMR spectrometer

5. To determine the absorption coefficient of gamma-rays in given material using NaI(Tl) detector.

6. To determine the absorption coefficient of beta particles in aluminum using GM counter

7. To study: (a) X-rays produced by X-ray tube (b) absorption of copper K X-rays in Al by varying the thickness of Al targets.

8. (a) to determine the Planck's constant and (b) to verify Moseley's law using X-ray apparatus.

9. To find absorption coefficient of Copper K X-rays in V, Cr, Mn, Fe, Co, Ni, Cu and Zn.

10. To study the diffraction spectrum of Copper K X-rays diffracted from given single crystal.

11. To study the diffraction spectrum of Copper K X-rays diffracted from given crystalline powder.

Microwaves:

12. To find the wavelength of microwaves using Klystron-tube based X-band microwave-bench working in TE_{10} mode and also to determine the VSWR at different loads.

13. To determine the dielectric constant of given liquid at X-band frequency using Von-Hippel's method.

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14. To study Gunn oscillator as a source of microwaves and to find the wavelength of microwaves.
15. To set up the X-band resonator cavity and use it to determine the dielectric constant of given material.

Practicals: 96 Hrs **Total: 96 Hrs**

C/BOS

PH-9201 Condensed Matter Physics-II LTPC/4105

Course Outcomes:

After successful completion of the course, the students should be able to

CO1: Generalize the concepts of physical phenomena in condensed matter.

CO2: Describe the motion of electron in solids with different approximations.

CO3: Describe the effect of doping on the electronic properties of semiconductors

CO4: Apply the kinetic theory of gases and basic rules of vacuum science.

CO5: Select the most appropriate film deposition process to achieve a desired outcome.

CO6: Understand processing techniques for nanomaterials and different methods for its characterization and application.

CO/PO Mapping S-strong, M-medium and W-weak indicate the strength of correlation												
COs	Programme outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							S	S	S	S		
CO2					M						M	S
CO3	S		S	M								
CO4	S	M			S	S						
CO5	S				S	S						M
CO6	S		S	S	S		S			S		M

PH-9201 Condensed Matter Physics-II LTPC/4105

UNIT I

Electronic Properties of Solids and Energy Bands: Electron in periodic lattice, Bloch theorem, Kronig-Penny model and band theory, Brillouin zones, effective mass, classification of solids on the basis of band theory, Intrinsic carrier concentration, Donors and Acceptors, Direct and Indirect band semiconductors, weak-binding method and its application to linear lattice, tight-binding method, Fermi surface: construction of Fermi surface in two- dimension, de Hass van alfen effect. Elementary ideas of quantum Hall effect. **20L**

Vacuum technology: Basic ideas about vacuum, throughput, conductance, Vacuum pumps: rotary pump, diffusion pump, ion pump, molecular pump, cryopump, vacuum gauges: pirani gauge, penning gauge and ionisation (hot cathode and cold cathode Ionisation) gauges.**10L**

UNIT II

Thin films: Thin film and growth process, Thins Film Deposition Techniques: Physical vapour deposition: thermal evaporation, sputtering and laser ablation, chemical vapour deposition, spray pyrolysis, Thin film thickness measurement techniques: film resistance method, optical method and microbalance method. **15L**

Nano Structural Materials and its Characterization: Definition and properties of nanostructured materials. Methods of synthesis of nanostructured materials, experimental techniques for characterization nanostructure materials (electron microscopy, Transmission electron microscopy, scanning electron microscopy, Auger electron microscopy, atomic force microscopy), New forms of carbon – fullerenes, nanowires and nanotubes. **15L**

Total: 60L

BOOKS:

1. Solid State Physics by C. Kittel
2. Quantum theory of Solids - Charles Kittel
3. Multiple beam interferrometry by Tolansky
4. Vacuum science and Technology by V.V.Rao, T.B.Ghosh and K.L.Chopra
5. Physics of Thin Films by K. L. Chopra
6. Principles of Condensed Mater Physics by P.M. Chaikin and T.C. Lubensky.
7. Solid State Physics: N.W. Ashcroft and N.D. Mermin
8. Handbook of Nanotechnology by Bharat Bhushan.
9. Handbook of Nanostructured Materials and Nanotechnology (Vol. 1 to 4). Ed. Hari Singh Nalwa

C/BoS

PH-9202 Laser and its Applications LTPC/4105

Course Outcomes:

After successful completion of this course, the students should be able to

CO1: Understand the basic principle and properties of LASER action.

CO2: Study the control and different modes of LASER operation.

CO3: Understand the principle and working of different Lasers.

CO4: Study the application of lasers in material processing, medical sciences, physical measurements, spectroscopy and holography

CO5: Understand the LASER hazards and safety methods.

CO/PO Mapping
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes(POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2					S							
CO3							S					M
CO4			S				S					
CO5						M			S			

C/BoS

PH-9202 Laser and its Applications LTPC/4105

UNIT-I

Basics of Lasers: Properties of laser beams: Intensity, monochromaticity, coherence, directionality, and brightness.

Interaction of radiation with matter: Absorption & stimulated emission, line broadening mechanism, transition cross section, absorption & gain coefficient, gain saturation (homogenous and inhomogeneous broadened line), spatial hole burning, spectral hole burning, Lamb dip.

Continuous wave and transient laser behavior: Rate equations (Four level and three level laser). CW laser behavior, power in laser oscillator, optimum output coupling, single mode oscillation, reasons for multimode oscillations, and active stabilization of laser frequency, Frequency pulling, relaxation oscillations in single mode lasers. **20L**

Optical Resonators: Fabry Perot interferometer, photon life time and cavity Q, plane parallel resonator, confocal resonator, generalized spherical resonators, stable and unstable resonators. Gain switching, cavity dumping, Q-switching and mode locking: Active and passive mode locking.

10L

UNIT-II

Principle and Working of Different Lasers: Gas Lasers: CO2 laser, Argon ion laser. Excimer lasers, He-Ne Laser, Solid and Liquid Lasers: Neodynium-YAG laser. Neodymium glass laser. Ruby Laser, Dye Lasers. Chemical lasers: HF, DF & Free electron lasers, Semiconductor diode lasers. Homostructure and Heterostructure, Double Hetro Structure p–n junction lasers, Quantum Well Lasers. **13L**

Laser Applications: Laser in measurements: Measurement of length; homodyne and heterodyne interferometry, speckle metrology, laser Doppler velocimetry, measurements of rate and rotation using laser gyroscope, LIDAR. LAser Radar.

Holography: The wavefront reconstruction process: Inline hologram, the off axis hologram, Fourier hologram, the lens less Fourier hologram, image hologram.

The reconstructed image: Image of a point, image magnification, Thin hologram, Thick (volume) hologram.

Industrial applications of LASERS: Hole drilling, cutting & welding with Lasers.

Laser in Medical Sciences: LASER diagnostics, Lasers in Dermatology and cardiology and ophthalmology (qualitative idea).

Laser in spectroscopy: Absorption spectroscopy, Laser induced fluorescence, RAMAN spectroscopy, LASER induced breakdown spectroscopy, Confocal LASER microscopy.

Use of laser at particle accelerators (qualitative idea only).

Laser Hazards and laser safety. **17L**

Total: 60L

BOOKS:

1. A.K.Ghatak and K.Thyagrajan, Optical Electronics,(Cambridge Univ. Press, 1989).
2. D.C.O.Shea. An Introduction to Lasers and Their Application (Addision -Wesley. Reading, 1978)
3. K. Shimoda, Introduction to Laser Physics (Springer Verlag, Berlin, 1984)
4. K. Thyagrajan and A.K.Ghatak, Laser: Theory and Applications. (McMillan India. New Delhi, 1984).
5. Laser Principles and Applications by J.Wilson and Hawkens.
6. O.Svelto, Principles of Lasers, (Plenum, New York, 1982).
7. B.B. Laud, Laser & Non linear optics, (Wiley Eastern, 1991)

C/BOS

PH-9203 **Digital Electronics** **LTPC/4105**

Course Outcomes:

After successful completion of the course, the students should be able to

CO1: understand the basic knowledge about components of digital electronics.

CO2: apply Boolean algebra and basic theorems to digital circuits.

CO3: use properly the various digital components in digital circuit diagrams.

CO4: explain the overall function of digital circuit.

CO5: design the microprocessor based programs for basic mathematical operations.

CO/PO Mapping S-strong, M-medium and W-weak indicate the strength of correlation												
COs	Programme outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	W	W	W		W			S		W	S
CO2	S	S	S	M	S		M	W		W		M
CO3	S	W	M	W	W	S	S	S	S	M	S	S
CO4	S	S	W		W	M			M	S	W	W
CO5	M	W	S	W			S	M			M	

C/BOS

PH-9203 **Digital Electronics** **LTPC/4105**

UNIT-I

Number system: Decimal, binary, hexadecimal, octal and their inter-conversion, 1's and 2's representation, signed and unsigned numbers; binary addition, subtraction, multiplication; alphanumeric, BCD, gray codes and inter-conversion from binary to gray and gray to binary ; Logic gates: AND, OR, NOT, NOR, NAND, XOR, XNOR and their truth tables; Development of Boolean Algebra, Boolean Algebra and logic gates, Laws of Boolean algebra. Demorgan's theorems, principle of duality, SOP, POS, min and max terms; Karnaugh Maps (upto four variables), Don't care conditions. **15L**

Digital Circuits: Combinational Logic Circuits, logic levels, half and full adder, half and full subtractor, Decoders, Encoders, Multiplexers, De-multiplexers, Parity generators and checkers. Analog to Digital Conversion: counter, successive approximation, tracking, flash types; Digital to Analog Conversion: Weight resistor, R-2R ladder, switched current and capacitor source types. **15L**

UNIT-II

Data Storage Circuits: Sequential circuits, FF and latches, triggering and operating characteristics of FF, SR, D, T and JK FF, race around condition and MS FF; inter-conversions of FF's. applications of FF, Shift registers: PIPO, PISO, SISO, SIPO, bidirectional, universal and applications of shift registers; Counters: ripple, asynchronous -two bit, mod-6, mod-10, T FF; Synchronous -three bit JK FF, three bit up/down, mod-6, 10 up/down T FF, mod-6 JK FF, ring counters. Basics of semiconductor memories: ROM and its types and organization. **20L**

Microprocessors: Basic architecture of INTEL 8085 Microprocessor (block diagram approach), Assembly language (AL), Machine language (ML), Programming of 8085 Microprocessor, Instructions for simple mathematical operations e.g.: Addition, Subtraction, Multiplication and Division. **10L**

Total: 60L

BOOKS:

1. Integrated Electronics-Millman and Halkias-Tata Mc Graw Hill, 1983.
2. Solid Principles and Applications - Malvino & Leach-Tata Mc Graw Hill, 1991.
3. Pulse, Digital and Switching Waveforms – Millman and Taub-New York Mc Graw Hill, 1965.
4. Physics of Semiconductor Devices - S M Sze-John Wiley & Sons, 1969.
5. Linear Integrated Circuits – D Roy Choudhary
6. Digital Computer Electronics- A.P. Malvino-Tata Mc Graw Hill, 1986

c/BOS

w.e.f. July, 2018

PH-9204 **RADIATION PHYSICS** **LTPC/4105**

Course outcomes

The objective of the course on Radiation Physics is to provide an introduction to the students to understand,

CO1: The aspects of radioactive sources (alpha, beta, gamma and neutron sources). The detailed description of the nuclear accelerators (linear and Circular accelerators) and the description of synchrotron radiations.

CO2: The interaction, scattering and processes of energy losses of charged particles, and the photons in the matter.

CO3: The interaction of neutron with matter. Description of neutron diffusion and moderation in multiplying and non-multiplying media.

CO4: The aspects of various nuclear detectors used for the detection of charged particle, photons and the neutrons.

CO5: The description of the radiation effects in condensed system, radiolysis of water and the aspects of the dosimetry.

CO6: The importance of modern application of radiations; radiotherapy, radiation image techniques etc.

CO/PO Mapping

(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes (Pos)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2		S										
CO3			S									
CO4				M								
CO5	S				S							
CO6		S										S

c/BOS

PH-9204 RADIATION PHYSICS LTPC/4105

UNIT-I

Sources of Radiation: Cosmic rays, Radioactive sources, Accelerators; Brief study of principle of operation & characteristics of radiations of Cockroft Walton. Vande Graff, Cyclotron, Electron Linac, Electron Synchrotron, Synchrotron radiation: Polarization, coherence and emittance. Neutron Source: Reactors, Neutrons from charged particle and photon induced reactions. Radiation Protection: Units and special parameters, background levels, radiation carcinogenic. **10L**

Interaction of Charged particle with matter: Definition of range, types of charged particle interaction, energy transfer in elastic collisions, Bethe formula, scattering of heavy and light charged particles, Radiation loss: corrections for Born approximations and Bremsstrahlung. **10L**

Interaction of Photons: Attenuation coefficients, classical scattering from single electrons, coherent scattering, Compton scattering: The Klein–Nishina cross section (No derivation), Atomic electrons: Effect of electron binding, electron recoil energy, electron momentum distributions from Compton profiles. Photoelectric absorption, characteristic X-rays, Auger electrons, pair production. **10L**

UNIT-II

Interaction with Neutrons: Neutron interactions, Definition of flux, current density, collision dynamics, distribution of energy and angle of scatter, Mean scatter angle and energy loss in single collision, extension to multiple collision, neutron diffusion and moderation: Diffusion equation and its solutions: non-multiplying and multiplying media, Neutron slowing down and thermalization. **8L**

Nuclear detectors: Gas detectors, Scintillation detector, semiconductor detectors. Analysis of the spectrum measured with NaI(Tl) and Semiconductor detectors. **8L**

Dosimetry and Mircodosimetry: Dosimetric Principles, Quantities and units, Relationships between various Dosimetric quantities, Dosimetry, Calorimetry, standardization for low and medium energy X-rays, high energy photons, electrons, chemical dosimeters, TLD, solid state and film dosimeters. Experimental determinations of micro-dosimetric spectra. **5L**

Radiation effects: Stochastic and Non Stochastic effects, Radiation effects in condensed systems, radiolysis of water. Brief discussion of Radiotherapy using Photons, electrons and heavy particle. **5L**

Brief introduction to radiation imaging techniques: Diagnostic radiology, Tomography, Magnetic Resonance Imaging, Nuclear Medicine (Qualitative). **4L**

Total:60L

BOOKS:

1. A primer in Applied Radiation Physics, F.A. Smith, World Scientific
2. Radiation Oncology Physics: E.B. Podgorsak, Technical Editor; A handbook for teachers and students: International Atomic Energy agency
3. Radiation Detection and Measurement, G.F. Knoll, John Wiley

C/BOS

PH-9251 Physics Lab-III *(Materials Science and Digital Electronics)* *LTPC/0084*

Course Outcomes:

After successful completion of the course, the students should be able to

CO1: verify the theoretical formulations/ concepts of physics.

CO2: know the art of recording the observations of an experiment scientifically.

CO3: learn by doing.

CO4: handle and operate the various elements/parts of an experiment.

CO5: understand the importance of physics experiments in engineering & technology.

CO/PO Mapping S-strong, M-medium and W-weak indicate the strength of correlation												
COs	Programme outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S											
CO2		S										
CO3				S								
CO4											M	
CO5							M					

C/BOS [illegible]

PH-9251 Physics Lab-III *(Materials Science and Digital Electronics)* *LTPC/0084*

Condensed Matter Physics:

1. To trace hysteresis loop and calculate the retentivity, coercivity and saturation magnetization.
2. To determine the dielectric constant of ferroelectric ceramics and also to determine the Curie temperature of ferroelectric ceramics as well as ferrite material.
3. To determine the band gap of a semiconductor using:
   a) PN junction diode.
   b) four probe method
4. To study Hall effect in a semiconductor and to determine (i) Hall voltage and Hall coefficient (ii) the number of charge carriers per unit volume (iii) mobility of charge carriers.
5. To study Hall effect in given metal and to determine (i) Hall voltage and Hall coefficient (ii) the number of charge carriers per unit volume (iii) mobility of charge carriers.
6. To determine the velocity of ultrasonic waves in a given liquid using ultrasonic interferometer.
7. To determine the transition temperature of a high temperature superconductor.
8. To prepare a metallic sample and measure the grain size using metallurgical microscope.
9. To find the capacitance and permittivity of the given material.
10. Dispersion relation of monoatomic and diatomic lattice.

Digital Electronics:

11\. (a) To study logic gates: OR, AND, NOT, NOR, NAND, XNOR and XOR.
(b) To verify De-Morgan's theorems.

11\. To study: encoder, decoder and ALU

12\. To study shift registers; and half and full adder/subtractor circuits

14\. To study:
a) ADC and DAC
b) pulse width and pulse position modulation/demodulation

15\. To study the microprocessor 8085 for simple programming: addition, subtraction, multiplication and division.

Practical: 96 Hrs **Total: 96 Hrs**

C/BOS

PH-9252: Project Work

Project allotment

M.Sc. Project to students of M.Sc. final year with a ratio of 1:1 only with respect to number of regular faculty members in the Department of Physics will be offered on *Merit (in the 1st year of* ***M.Sc.)-cum-Option of the student*** basis before the end of the 3rd semester and rest of the students will do **Physics Lab-III (Materials Science & Digital Electronics)**.

Aim of Project

The aim of project work in M.Sc. 4th semesters is to expose the students to some of the preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc.

Project Guidelines

- Project work can be in Experimental Physics or Theoretical Physics in the thrust as well as non-thrust research areas of the department.
- A brief synopsis on the research project to be carried out by the student has to be submitted to the Departmental Research Committee (DRC) within first week at start of the academic session of the 4th semester.
- Finally, a report/thesis of about 60-80 pages on the work done in the project (typed on single side of the page properly hard bound) will be submitted by a date to be announced by the Departmental Research Committee (DRC).
- Assessment of the work done under the project will be carried out by a committee on the basis of efforts put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc as per guidelines prepared by the Departmental Research Committee (DRC).
- This load (equivalent to 8 hours per week for each student) of research project will not be counted towards the normal teaching load of the teacher.

Seminar

- Students pursuing M.Sc. Projects in the 4th Semester have to give regular seminars along with the final seminar on the project duly supported by the use of multimedia and evaluation will be carried out by Departmental Research Committee (DRC).

Members of DRC

All Prof., Concerned Supervisors and Chairman of DRC (HOD)

11.6.18 11/06/18 11/6/18 Kaur 11/06/18 11-06-2018 (K.S. Mann)

Deepali 11/6/18 Jagwinder Singh 11/6/18 11/6/18 11/6/18

REPORT/THESIS WRITING

A report/thesis of about 50 pages on the work done in the project typed on single side of the page with 1.5 line spacing, Times New Roman font with 14 size for titles and 12 size for sub-titles and reaming text and properly hard bound. Overall contents of the report/thesis should be generally in the following order:

- Title page
- Acknowledgements
- Certificate
- Abstract
- List of figures or illustrations
- Introduction
- Aims and objectives
- Literature survey
- Scope and constraints
- Resources
- Methodology/Experimental Method
- Results
- Discussion
- Conclusion
- Future recommendations
- Reference List/Bibliography
- Appendices

11/06/18

11/6/18

Rau 11/06/18

Deepali 11/6/18

Jagwinder Singh 11/06/18

11.6.2018 (K.S. Mann)

11/6/18

11/6/18

11.6.18