1.1.3 Courses having focus on employability/ entrepreneurship/ skill development offered by the University during the year

Color Index	
Employability	Yellow
Entrepreneurship	Green
Skill Development	Pink

SYLLABUS

MASTER OF SCIENCE- PHYSICS

(TWO-YEAR FULL-TIME PROGRAMME)

(FOUR SEMESTER COURSE)

Department of Physics

<u>School of Basic & Applied Science</u>

Lingaya's Vidyapeeth, Faridabad

Deemed to be university (u/s of UGC act 1956)

(Approved By UGS, MHRD, AICTE, BCI, PCI & ACI)

SCHEME OF EXAMINATION

(Continuous Assessment and End-Semester Examination)
Theory Courses

Sub-component	Weightage
MID-Semester Examination	**25**
Assignment/Quiz/Tutorial/Viva-voce (**ABQ)**	**15**
End-Semester Examination	**60**

Practical Components/Practical Courses

Examination	Sub-component	Weightage	Total
Internal examination	Viva-voce + Continuous lab performance	**20+20**	**40**
End-Semester Practical Exam (External examination)	Viva-voce + Written exam + Practical record file	**20+25+15**	**60**

LINGAYS'S VIDYAPEETH, FARIDABAD
PROGRAMME STRUCTURE
M.Sc. Physics

M.Sc. Physics	Course No.	Course Code	Course Name	Credit/week
I (Odd)	1.	MPH–101	Mathematical Physics-I	3+1+0 = 4
	2.	MPH–103	Classical Mechanics	3+1+0 = 4
	3.	MPH–105	Quantum Mechanics-I	3+1+0 = 4
	4.	MPH–107	Electronics	3+1+0 = 4
	5.	MPH–109	Condensed Matter Physics- I	3+1+0 = 4
	6.	MPH–151	Physics Laboratory-I	0+0+3 = 2
			Total	**22**
II (Even)	7.	MPH–102	Mathematical Physics-II	3+1+0 = 4
	8.	MPH-104	Atomic & Molecular Physics	3+1+0 = 4
	9.	MPH–106	Thermodynamics and Statistical Physics	3+1+0 = 4
	10.	MPH–108	Classical Electrodynamics	3+1+0 = 4
	11.	MPH–110	Quantum Mechanics-II	3+1+0 = 4
	12.	MPH–152	Physics Laboratory-II	0+0+3 = 2
	13.	MPH-112	Research Methodology	3+1+0 = 4
			Total	**26**
III (Odd)	14.	MPH–201	Advanced Condensed Matter Physics	3+1+0 = 4
	15.	MPH–203	Nuclear & Particle Physics	3+1+0 = 4
	16.	MPH-205	Material Science (F)	3+1+0 = 4
	17.	MPH–207	**Special Paper (Anyone)** (I) Advanced Electronics (II) Integrated Circuit Fabrication (III) Accelerator Physics (IV) Plasma Physics (V) Science of Renewable Energy Sources	3+1+0 = 4
	18.	MPH–209	**Special Paper (Anyone)** (I) Advanced Nano Physics (II) Fibre optics and Non-linear Optics (III) Advanced Nuclear & Particle Physics (IV) High Energy Physics	3+1+0 = 4
	19.	MPH-251	Computational Physics Laboratory	0+0+3 = 2
	20.	MPH-253	Synopsis Seminar	0+0+2 = 1
	21.	MPH-255	**Dissertation (**Literature Search and Review; Synopsis Submission**)**	0+0+8 = 4
			Total	**27**
IV (Even)	22.	MPH–252	**Dissertation (**Literature Search and Review; Thesis Submission**)**	0+0+40 = 20
			Total	**20**
Total Credits				**95**

SEMESTER-I

MPH-101: Mathematical Physics - I

(Semester I)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
The main objective of this course is to familiarize students with a range of mathematical methods that are essential for solving advanced problems in theoretical Physics.

COURSE OUTCOMES:

CO1: Use complex analysis in solving physical problems.
CO2: Use delta and gamma functions.
CO3: Use the orthogonal polynomials and other special functions.
CO4: Use Fourier series and integral transformation.

Unit	Contents	Lectures
I	**Vector algebra & Vector Calculus:** Review of vector algebra, Gradient of a Scalar Field and its geometrical interpretation, Divergence, and Curl of Vector Field, Line, Surface, and Volume integrals, Gauss's Divergence Theorem, Stoke's & Green's Theorem, simple problems .	10
II	**Delta and Gamma Functions:** Dirac delta function, Delta sequences for one-dimensional function, properties of the delta function, Gamma function, factorial notation and applications, Beta function.	8
III	**Integral transforms:** Laplace transform, some simple properties of Laplace transform, Inverse Laplace Transform, Laplace transform of derivatives, Laplace Transform of integrals.	8
IV	**Fourier series:** Fourier series and its properties, Evaluation of coefficients of Fourier series (Euler's formulae), Fourier sine & cosine Transforms, and physical applications of Fourier series.	9
V	**Matrices:** Brief review of matrices, Orthogonal and unitary matrices, Solution of linear equations, Eigen values and Eigen vectors, Diagonalization of matrices, Caley-Hamilton theorem. Tensors: Introduction, definitions, contraction, direct product. Quotient rule, Levi-Civita symbol, Non-cartesian tensors, metric tensor, covariant differentiation.	17

REFERENCE BOOKS:

1. Mathematical Methods for Physicists: G Arfken, HJ Weber, Academic Press, SanDiego, 7th ed., 2012.
2. Mathematical Physics: PK Chattopadhyay, Wiley Eastern, New Delhi, 2004.
3. Mathematical Physics: AK Ghatak, IC Goyal, SJ Chua, MacMillan, India, Delhi,1986.
4. Mathematical Methods in the Physical Sciences: M Boas , Wiley, New York, 3rd ed., 2007.
5. Mathematical Physics, by H.K. Dass, Pragati Prakashan
6. Mathematical Physics by B.S. Rajput, 30th Edition, 2017.

POs / COs	PO1	PO2	PO3	PO4	PSO1	PSO2	PSO3	PSO4

CO1	2	3	-	1	3	2	3	1
CO2	2	3	1	-	1	2	1	-
CO3	3	3	-	2	1	2	-	-
CO4	2	3	-	-	2	1	-	-

MPH-103 : Classical Mechanics
(Semester I)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
To demonstrate knowledge and understanding of the following fundamental concepts in:
The dynamics of system of particles, motion of rigid body, Lagrangian and Hamiltonian formulation of mechanics.

COURSE OUTCOMES:
CO1: Use a standard process for analyzing static objects.
CO2: Add forces and moments in two and three dimensions and find a component of a force or moment in each direction.
CO3: Describe conditions of equilibrium and their associated component equations.
CO4: Use conditions of equilibrium and known forces and moments to solve for unknown external and internal forces and moments present in an object of system of connected objects.

Unit	Contents	Lectures
I	**Lagrangian Formulation:** 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.	**10**
II	**Hamilton's Principles:** Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principal formulation, symmetry properties of space and time and conservation theorems. Hamilton's Equations: Legendre Transformation, Hamilton's equations of motion, Cyclic-co-ordinates, Hamilton's equations from variational principle, Principle of least action.	**11**
III	**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.	**11**
IV	**Rigid Body Motion:** Independent co-ordinates 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	**11**

	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.	
V	**Small Oscillations:** Eigenvalue equation, Free vibrations, Normal Coordinates, Vibrations of a tri-atomic molecule.	**9**

REFERENCE BOOKS:

1. Classical Mechanics by H. Goldstien (2nd Edition).
2. Berkely Physics Course. Vol. 1. Mechanics by E.M.Purcell
3. Properties of Matter by D.S. Mathur.
4. R. Resnick : Introduction to Special Relativity
5. Physics for Engineers, Vol.1, B.S. Rajput and M.P. Singh

POs COs	PO1	PO2	PO3	PO4	PSO1	PSO2	PSO3	PSO4
CO1	1	3	-	-	2	2	1	1
CO2	1	3	1	1	1	2	1	3
CO3	1	3	-	-	1	2	-	1
CO4	2	3	1	1	2	1	-	-

MPH-105: Quantum Mechanics-I
(Semester I)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

Connect the historical development of quantum mechanics with previous knowledge and learn the basic properties of quantum world

COURSE OUTCOMES:

CO1: Understand and explain the differences between classical and quantum mechanics.
CO2: Understand the idea of wave function and uncertainty relations.
CO3: Solve Schrodinger equation for simple potentials.
CO4: Spot, identify and relate the eigenvalue problems for energy, momentum, angular momentum and central.

Unit	**Contents**	**Lectures**

I	**Mathematical Tools of Quantum Mechanics:** Hilbert space and wave functions, Dirac's bra and ket notation, Schwarz inequality, Orthonormal basis; Operators: Projection operator, Hermitian and Unitary operators; Commutators and Heisenberg uncertainty principle, change of basis, Eigenvalues and Eigenvectors of an operator, matrix mechanics, Harmonic oscillator in matrix mechanics; Postulates of quantum mechanics, Time development of states and operators, Schrödinger and Heisenberg representations; problems related to particle in a box and tunneling through a barrier.	**12**
II	**Angular Momentum:** Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. eigenvalues and eigenvectors of L^2 and L_z, Spin angular momentum, Total angular momentum, Eigenvalues, and eigenvectors of J^2 and J_z. Spherical Harmonics, Addition of angular momenta, C.G. coefficients.	**11**
III	**Stationary State Approximate Methods:** Non-Degenerate and degenerate perturbation theory and its applications, Variational method and WKB method with applications to the ground states of harmonic oscillator and other simple systems.	**10**
IV	**Time Dependent Perturbation:** General expression for the probability of transition from one state to another, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light.	**10**
V	**Scattering Theory:** Scattering Cross-section and scattering amplitude, born approximation and its application to Yukawa potential and other simple potentials, Partial wave analysis, Low energy scattering, Optical theorem, Scattering of identical particles.	**9**

REFERENCE BOOKS:

1. Quantum Mechanics: Concepts and Applications: Nouredine Zettili, Wiley, India, 2nd edition, 2016
2. A Text book of Quantum Mechanics, PM Mathews, K Venkatesan, Tata McGraw Hill, New Delhi, 2nd ed., 2004.
3. Modern Quantum Mechanics : JJ Sakurai, Addison Wesley, Reading, 2004.
4. Quantum Mechanics : VK Thankappan, New Age, New Delhi, 2004.
5. Quantum Physics : S Gasiorowicz, Wiley, New York, 3rd ed. 2003.

POs COs	PO1	PO2	PO3	PO4	PSO1	PSO2	PSO3	PSO4
CO1	2	3	1	1	2	2	1	1
CO2	2	3	1	-	1	2	1	-
CO3	1	3	-	-	1	2	-	1
CO4	2	3	-	2	2	1	2	-

MPH-107: Electronics
(Semester I)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**

Contact hours : **52** End-semester exam : **55**

OBJECTIVES:
To introduce students to entire circuit designs, and to provide in-depth theoretical base of Digital Electronics. The Electronics course covers basic circuit analysis, first-order nonlinear circuits, Analysis of Passive and Active filters, OPAMP based analog circuits and introduction to various registers and counters.

COURSE OUTCOMES:
CO1: Understanding of Fundamentals and properties of semiconductor devices.
CO2: Logic circuits, digital systems and microprocessor and their peripheral devices.
CO3: Operating and designing digital systems.
CO4: How to solve problems in design and/ or implementation of digital.

Unit	Contents	Lectures
I	**Digital Electronics:** Logic gates-Boolean algebra and De-Morgan's theorem; Boolean laws and theorem-Sum-of-Products and Products-of-Sums method-Karnaugh simplifications; Multiplexers and Demultiplexers; BCD-to-Decimal Decoders-Seven-segment decoders; Decimal-to-BCD encoder; Half-adder and Full-adder circuits. Multiplexers and Demultiplexers	14
II	**Operational Amplifiers:** The ideal Op-Amp-inverting, non-inverting, and differential amplifiers. Op-Amp applications-adder, subtractor, integrator, differentiator, comparator, voltage-to-current converter, current-to-voltage converter, and logarithmic amplifier.	12
III	**Flip-Flops:** Types of Flip-Flops-RS Flip-Flop, Clocked RS Flip-Flop, D Flip-Flop, J-K Flip-Flop, and J-K Master-Slave Flip-Flops; Schmit Trigger; 555 Timer-A stable and Monostable circuits.	10
IV	**Registers:** Types of Registers-Serial in-Serial out, Serial in-Parallel out, Parallel in-Serial out, Parallel in-Parallel out Registers.	8
V	**Counters:** Types of Counters-Ring Counters, Asynchronous and Synchronous Counters, Shift Counters; D/A and A/D Converters.	8

REFERENCE BOOKS:
1. Textbook of Electronics by S. Chattopadhyay, New Central Book Agency P.Ltd., Kolkata, 2006.
2. Digital Principles and Applications by A.P. Malvino and D.P. Leach, Tata McGraw-Hill, Publishing Co., New Delhi.
3. Electronics Principles by Malvino, 6th Edition, Tata McGraw-Hill Publishing Co., New Delhi, 2001.
4. Electronics Principles and Applications by A.B. Bhattacharya, New Central Book Agency P.Ltd., Kolkata, 2007.
5. Integrated Electronics: Analog and Digital Circuits and Systems, Jacob Millman and Christos C. Halkias, Tata McGraw-Hill.
6. Handbook of Electronics, Gupta & Kumar, Pragati Prakashan.

POs COs	PO1	PO2	PO3	PO4	PSO1	PSO2	PSO3	PSO4
CO1	2	3	-	1	2	2	1	1
CO2	2	3	1	1	1	3	1	-
CO3	1	3	1	2	1	2	-	-
CO4	2	3	-	3	2	1	-	-

MPH-109: Condensed Matter Physics-I

(Semester I)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

To introduce students to entire circuit designs, and to provide in-depth theoretical base of Digital Electronics. The Electronics course covers basic circuit analysis, first-order nonlinear circuits, Analysis of Passive and Active filters, OPAMP based analog circuits and introduction to various registers and counters.

COURSE OUTCOMES:

CO1: Understand and explain elastic behavior and its types.
CO2: Understanding of Einstein and Debye model.
CO3: To solve the problems related to transport theory.
CO4: Experimental of liquid crystal basics.

Unit	Contents	Lectures
I	**Elastic Properties:** Elastic behaviour and its atomic model, Hooke's law, Relaxation processes, Viscoelastic behaviour, Binding in solids; analysis of elastic strain, elastic compliance and stiffness constants, elastic waves in crystals.	**10**
II	**Thermal Properties:** Phonon heat capacity: Einstein and Debye model of density of states, Debye T^3 law; Anharmonic crystal interactions: thermal expansion, thermal conductivity.	**10**
III	**Energy Band Theory:** Electrons in a periodic potential: Bloch theorem, Kronig-Penney model, nearly free electron model; calculation of energy bands using tight binding method; Semiconductor Crystals, equation of motion of electron and hole in an energy band, effective mass and its physical interpretation, effective mass in semiconductors, Band theory of pure and doped semiconductors; elementary idea of semiconductor superlattices.	**12**
IV	**Transport Theory:** Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magnetoresistance.	**10**
V	**Liquid Crystals:** Thermotropic liquid crystals, Lyotropic liquid crystals, long range order and order parameter, various phases of liquid crystals, applications, Physics of liquid crystal devices.	**10**

REFERENCE BOOKS:

1. Introduction to Solid State Physics: C Kittel, Wiley, New York, 8th ed., 2005.
2. Quantum Theory of Solids: C Kittel, Wiley, New York, 1987.
3. Principles of the Theory of Solids: J Ziman, Cambridge University Press, 1972.
4. Solid State Physics: H Ibach, H Luth, Springer Berlin, 3rd ed., 2002.

5. Solid State Theory: Walter A Harrison, Tata McGraw-Hill, New Delhi,1970.
6. Liquid Crystals: S Chandrasekhar, Cambridge University, 2nd ed.,1992.
7. The Liquid Crystal Phases: Physics & Technology : TJ Sluckin, Contemporary Physics, Taylor & Francis, 2000.

MPH-151: Physics Laboratory - I
(Semester I)

L+T+P	:	**0+0+3**	Viva-voce + Continuous lab performance	:	**40**
Credits:	:	**2**			
Contact hours	:	**26**	Viva-voce + Written exam + Practical record file	:	**60**

COURSE OBJECTIVES:
CO1: Experimental techniques in electronics.
CO2: Experimental experience on UJT, FET and MOSFET.
CO3: Experimental knowledge of Mulivibrators.
CO4: Experimental knowledge of Michelson Interferometer.

S. No.	Practical Description
1.	To determine the value of low resistance by using Kelvin double bridge.
2.	To determine the coefficient of self-inductance of a coil by Anderson bridge.
3.	To determine the capacitance of a capacitor using Schering bridge method.
4.	Study of Cathode Ray Oscilloscope and its various applications.
5.	Study of characteristics of semi-conductor devices (UJT, FET).
6.	To study the characteristics of a regulated power supply and voltage multiplier circuits.
7.	Study of integrating and differentiating circuits.
8.	Study of clipping and clamping circuits.
9.	Study of tunnel diode and Zener diode characteristics.
10.	Study of Oscillator circuits.
11.	Designing and study of Op-Amp: Characteristics and parameter measurements.
12.	Study of multi vibrators (a) a stable (b) bi-stable (c) mono-stable.
13.	To determine the value of Plank's constant using a photo-electric cell.
14.	To determine the value of Cauchy's Constant for the material of given prism using a mercury vapor lamp.
15.	To determine the value of e/m for electron by helical method.
16.	Determination of wavelength and difference in wavelengths of sodium lines using Michelson Interferometer.
17.	Determination of thickness of mica sheet using Michelson Interferometer.
18.	To determine the velocity of ultrasonic waves in each liquid.

SEMESTER-II

MPH-102: Mathematical Physics - II

(Semester II)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
The main objective of this course is to familiarize students with a range of mathematical methods that are essential for solving advanced problems in theoretical Physics.

COURSE OUTCOMES:
CO1: Use complex analysis in solving physical problems.
CO2: Use of the differential equations.
CO3: Use of the special functions and solve related problems.
CO4: Use of numerical techniques.

Unit	Contents	Lectures
I	**Elements of Probability:** Definition of probability, Theorem of total probability, Random variables, Poisson Law, Constants of some important distributions: Binomial, Normal and Poisson distributions.	**9**
II	**Differential Equations:** Linear Equations with variable Coefficients: Equations of the second order, series solutions of Linear Differential Equation of second order.	**9**
III	**Special functions:** Basic properties (recurrence and orthogonality relations, series expansion) of Bessel, Legendre, Hermite and Laguerre functions.	**9**
IV	**Functions of Complex Variables:** Analyticity and Cauchy-Reimann Conditions, Cauchy's integral theorem and formula, Taylor's series and Laurent's series expansion, Zeros and singular points, Residues, Cauchy's Residue theorem.	**10**
V	**Numerical Techniques:** Finite differences, Interpolation, Differentiation, integration by trapezoid and Simpson's rule, Runge-Kutta method. Evaluation of definite integrals (around unit circle, infinite semi-circle using Jordan's lemma with poles lying on real axis and integration involving multiple valued function-branch point).	**15**

REFERENCE BOOKS:

1. Special Functions: ED Rainville, MacMillan, New York, 1960.
2. Mathematical Methods for Physicists: G Arfken, HJ Weber, Academic Press, San Diego, 7th ed.,2012.
3. Mathematical Physics: PK Chattopadhyay, Wiley Eastern, New Delhi, 2004.
4. Mathematical Physics: AK Ghatak, IC Goyal, SJ Chua, MacMillan, India, Delhi,1986.
5. Mathematical Methods in the Physical Sciences: M Boas , Wiley, New York, 3rd ed., 2007.

6. Mathematical Physics: PK Chatopadhyay, Wiley Eastern, New Delhi, 2011.
7. Introduction to Mathematical Physics : C Harper, Prentice Hall of India, New Delhi, 2006.

MPH-104: Atomic and Molecular Physics
(Semester II)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
This course deals principally with atomic structure and the interaction between atoms and fields. It covers electronic transitions, atomic spectra, excited states, hydrogenic and multi-electron atoms. Emphasis will be given to learn more detailed concepts of binding of atoms into molecules, molecular degrees of freedom (electronic, vibrational, and rotational), elementary group theory considerations and molecular spectroscopy.

COURSE OUTCOMES:
CO1: Understanding of the energy levels of the hydrogen atom and their effect on optical spectra.
CO2: Understanding of molecular quantum mechanics.
CO3: Explain the observed dependence of atomic spectral lines on externally applied electric and magnetic fields.
CO4; Understanding of interaction of atom with radiation.

Unit	Contents	Lectures
I	**Many-electron Atoms:** Review of He atom, Spectrum of Helium, and alkali atom. Ground state and first excited state, quantum virial theorem, Thomas-Fermi method, determinantal wave function, Hartree and Hartree-Fock method, periodic table, and atomic properties: ionization potential, electron affinity, Hund's rule.	10
II	**Molecular Quantum Mechanics:** Quantum states of an electron in an atom. Electron spin. Hydrogen molecular ion, hydrogen molecule, Relativistic corrections for energy levels of hydrogen atom, Hyperfine structure and isotope shift, width of spectrum lines, LS and JJ couplings.	11
III	**Atomic and Molecular Spectroscopy:** Fine and hyperfine structure of atoms, electronic, vibrational, and rotational spectra for diatomic molecules, role of symmetry, selection rules, term schemes, applications to electronic and vibrational problems.	10
IV	**Zeeman effect:** Pashchen- Bach- Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules.	10
V	**Interaction of Atoms with Radiation:** Atoms in an electromagnetic field, absorption and induced emission, spontaneous emission and linewidth, Einstein A and B coefficients, density matrix formalism, two-level atoms in a radiation field. Lasers: spontaneous and stimulated emission, Einstein A and B coefficients, Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.	11

REFERENCE BOOKS:

1. C. N. Banwell, Elaine M. McCash; Fundamental of molecular spectroscopy, McGraw- Hill.
2. C. A. Coulson, R. McWeeny,Coulson's Valence, Oxford University Press.
3. L.D. Landau and E.M. Lifshitz, Quantum Mechanics.
4. M. Karplus and R.N. Porter,Atoms and Molecules: An Introduction for Students of Physical Chemistry.
5. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics.
6. Elementary Particles: IS Hughes, Cambridge University, 3rd ed., 1991.

MPH-106: Thermodynamics & Statistical Physics
(Semester II)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

This course is advance course designed to introduce the students to advanced concepts and principles that can be used by the students to understand the Thermodynamics and Statistical Physics.

COURSE OUTCOMES:

CO1: Understanding of the thermos-dynamical properties of materials.
CO2: Learn the canonical and grand-canonical ensembles.
CO3: Bose-Einstein, Fermi-Dirac, and Maxwell- distributions.
CO4: Boltzmann distributions.

S. No	Contents	Lectures
I	**Thermodynamics, Microstates and Macrostates:** Basic postulates of thermodynamics, Fundamental relations and definition of intensive variables, Intensive variables in the entropic formulation, Intensive variables in the entropic formulation, Equations of state, Euler relation, densities Gibbs-Duhem relation for entropy, Thermodynamic potentials and extensivity properties, Maxwell relations, Energy differential and thermodynamic potentials of systems in external magnetic field, Thermodynamic relations, Microstates and macrostates Ideal gas – Microstate and macrostate in classical systems – Microstate and macrostate in quantum systems – Density of states .	**12**
II	**Microcanonical, Canonical and Grand canonical** Ensembles Microcanonical distribution function – Two level system in microcanonical ensemble – Gibbs paradox and correct formula for entropy The canonical distribution function – Contact with thermodynamics - Two level system in canonical ensemble – Partition function and free energy of an ideal gas – Distribution of molecular velocities – Equipartition and Virial theorems – The grand partition function – Relation between grand canonical and canonical partition functions – One-orbital partition function.	**10**
III	**Bose-Einstein, Fermi-Dirac Distributions:** Bose-Einstein and Fermi-Dirac distributions – Thermodynamic quantities – Fluctuations in different ensembles – Bose and Fermi distributions in microcanonical ensemble -	**10**
IV	**Maxwell-Boltzmann distribution:** law for microstates in a classical gas - Physical interpretation of the classical limit – Derivation of Boltzmann equation for change of states without and with collisions – Boltzmann equation for quantum statistics – Equilibrium distribution in Boltzmann equation. Bose Gas and Fermi Gas, Non-interacting Bose gas and thermodynamic relations	**10**
V	**Derivation of Boltzmann equation:** for change of states without and with collisions – Boltzmann equation for quantum statistics – Equilibrium distribution in Boltzmann equation. Bose Gas and Fermi Gas, Non-	**10**

	interacting Bose gas and thermodynamic relations.	

REFERENCE BOOKS:

1. An Introductory Course of Statistical Mechanics - Palash B. Pal, Narosa Publishing House (2008), New Delhi
2. Elements of Statistical Mechanics - Kamal Singh & S.P. Singh - S. Chand & Company, New Delhi.
3. Statistical Mechanics an Elementary Outline – AvijitLahiri – University Press - 2002- *Hyderabad.*

MPH-108: Classical Electrodynamics
(Semester II)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
The objective of the course is to present a theory of classical electrodynamics. Thus, Maxwell equations and their consequences are considered in detail. It is concerned with principles of the electromagnetic field theory and the description using Maxwell's equations.

COURSE OUTCOMES:
CO1: Understanding of motion of charged particles in electromagnetic fields, principles of the special theory of relativity.
CO2: Understanding of invariance of Maxwell equations.
CO3: Understanding the Lorentz transformation and their related problems.
CO4: Understanding the EM Field of a localized oscillating source.

Unit	Contents	Lectures
I	Coulomb's law, action-at-a distance vs. concept of fields, Poisson and Laplace equations, formal solution for potential with Green's functions, boundary value problems; multipole expansion; Dielectrics, polarization of a medium; Biot-Savart law, differential equation for static magnetic field, vector potential, magnetic field from localized current distributions; Faraday's law of induction; energy densities of electric and magnetic fields.	**10**
II	Maxwell's equations in vacuum. Vector and Scalar potentials in electrodynamics, gauge invariance and gauge fixing, Coulomb and Lorenz gauges. Displacement current. Electromagnetic energy and momentum. Conservation laws. Inhomogeneous wave equation and its solutions using Green's function method. (brief discussion).	**12**
III	Boundary value problems : Uniqueness theorem, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green's (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Magnetostatic boundary value problems	**10**
IV	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. boundary conditions at metallic surfaces, propagation modes in wave guides, resonant modes in cavities.	**10**

V	EM Field of a localized oscillating source. Fields and radiation in dipole and quadrupole approximations. Antenna: Radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula.	**10**

REFERENCE BOOKS:

1. Classical Electrodynamics : SP Puri , Narosa Publishing House, 2011.
2. Classical Electrodynamics : JD Jackson, New Age, New Delhi, 2009.
3. Classical Electromagnetic Radiation : JB Marion, MA. Heald, Saunders College Publishing House, 3rd ed., 1995.
4. Introduction to Electrodynamics: DJ Griffiths, Prentice Hall India, New Delhi, 4th ed.,2012.
5. Electromagnetic Fields: Ronald K Wangsness ,John Wiley and Sons, 2nd ed., 1986.
6. Electromagnetic Field Theory Fundamentals : Bhag Singh Guru, HR Hiziroglu, Cambridge University Press, 2nd ed., 2004.
7. Introduction to Electrodynamics : AZ Capri, PV Panat, Narosa Publishing House, 2010.

MPH-110: Quantum Mechanics-II

(Semester II)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

Connect the advance quantum mechanics with previous knowledge and learn the basic properties of quantum world

COURSE OUTCOMES:

CO1: Understand covariant from Dirac equation.
CO2: Understand the idea of Lagrangian dynamics of Classical fields.
CO3: Understand of the Canonical quantization.
CO4: Understanding the particle interpretation of Klein-Gordon field.

Unit	Contents	Lectures
I	The Klein Gordon equation, Covariant notations, Negative energy, and negative probability density. The Dirac equation, Properties of the Dirac matrices. The Dirac particle in an external electromagnetic field. The non-relativistic limit of the Dirac equation and the magnetic moment of the electron.	**10**
II	Covariant form of the Dirac equation. Lorentz covariance of the Dirac equation. Boost as hyper rotation Boost, rotation, parity, and time reversal operation on the Dirac wave function. Conjugate Dirac spinor and its Lorentz transformation. The $\gamma5$ matrix and its properties. Bilinear covariant and their properties. Boosting the wave function from the rest frame. Plane wave solutions of the Dirac equation and their properties. Energy and spin projection operators. The Hydrogen atom.	**10**
III	Concepts of fields. Lagrangian dynamics of Classical fields. Derivation of the Euler-Lagrange equation from Hamilton's variational principle. Lagrangian and equations of motion of fundamental fields. Noether's theorem. Invariances. Conserved currents and charges. Energy-momentum tensors and energy of fields**.**	**10**
IV	Canonical quantization and particle interpretation of the real Klein-Gordon field. Canonical quantization and energy of the Dirac field. Anti-commutators. Pauli principle. Equal time anti-commutator between the Dirac field and the canonically conjugate momentum field. Coulomb gauge quantization and energy of the Electromagnetic field.	**12**

V	A comparison between non-covariant and covariant quantization of the electromagnetic field. covariant quantization Basic ideas of the path integral formalism in quantum mechanics and quantum field theory**.** Interacting fields (mainly electromagnetic interaction). Lagrangian and equations of motion of a system of interacting electrons and photons.	**10**

REFERENCE BOOKS:

1. Relativistic Quantum Mechanics – J. D. Bjorken and S. D. Drell, McGraw-Hill, New York(1964).
2. Quantum Field Theory - Lewis H Ryder, Cambridge University Press (1985)
3. Quantum Field Theory - Claude Itzyksen and Jean-Bernard Zuber, McGraw Book Co. (1985)
4. Quantum Field Theory in a nutshell - A. Zee, Princeton University Press (2003).
5. A First Book of Quantum Field Theory – A. Lahiri and P. B. Pal, Narosa Publishing House (2001).
6. An Introduction to Quantum Field Theory by M. E. Peskin and D. V. Schroeder (Perseus Books).

MPH-152: Physics Laboratory-II

(Semester II)

L+T+P	:	**0+0+3**	Viva-voce + Continuous lab performance	:	**40**
Credits:	:	**2**			
Contact hours	:	**26**	Viva-voce + Written exam + Practical record file	:	**60**

OBJECTIVES:

The objective of the course General Physics Laboratory is to expose the students of M.Sc. class to experimental techniques in electronics, so that they can verify some of the things read in theory here or in earlier classes and develop confidence to handle sophisticated equipment.

S. No.	Practical Description
1.	To study temperature-dependence of conductivity of a given semiconductor crystal using four probe method.
2.	To determine the band gap of a semiconductor by Four Probe Method.
3.	To study the temperature dependence of a ceramic capacitor: Verification of Curie-Weiss law for the electrical susceptibility of a ferroelectric material.
4.	To study the characteristics of a LED and determine activation energy.
5.	To determine the Hall voltage, Hall coefficient and the carrier concentration of a given semi-conductor.
6.	To study the characteristics and dead time of a GM Counter.
7.	To study Poisson and Gaussian distributions using a GM Counter.
8.	To determine the electric charge of an electron using Millikan drop experiment.
9.	To study the molecular susceptibility of a given salt by Quincke's method.
10.	To Study the variation of modulus of rigidity and internal friction of a specimen rod with temperature.
11.	To determine the wave velocity and attenuation in solids by pulse method.
12.	To trace the B-H curve of a given material and to determine its magnetic parameters.
13.	Determination of magneto resistance of an extrinsic semiconductor.
14.	Determination of specific heat of solids (metals and alloys).
15.	Simulation of lattice dynamics of a mono-atomic and diatomic lattice.
16.	To design a rectangular/triangular waveform generator using Comparators.
17.	To determine the standing wave ratio and reflection coefficient
18.	Determining thickness of a thin wire by diffraction using laser beam.
19.	Study reflection, laws of reflection, internal reflection, critical angle, index of refraction of glass, index of refraction of prism, multiple internal reflection in glass and interference.

20.	Measure the wavelength of laser light with transmission grating.

MPH-112: Research Methodology
(Semester II)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
This course would focus on research methodology and making a good interpretation of research. It would also provide brief information about various instruments used for characterization purpose.
CO1: Understand the basic ideas about research methodology.
CO2: Able to understand research design.
CO3: Be able to learn about research techniques.
CO4: Understand the concept of research.

Unit	Contents	Lectures
I	**Research: a way of thinking:** Introduction to research, Research Process, defining research problem, Identification of a good research problem, Criteria for good research, Significance of research, Techniques for defining research problem, how to prepare yourself for research, Introduction to Research Methodology, Research design, Problems encountered by the researchers	**10**
II	**Data collection, interpretation, and research report:** Data collection, Interpretation of data, Field Research, Data analysis, Various Methods of Observation, Research Quoting, Interpretation is the climax of research process, Research paper Writing, Research work Presentations	**12**
III	**Instruments:** FTIR: Introduction, working principle, construction, merits, demerits, and applications. UV Spectrophotometer: Introduction, working principle, construction, merits, demerits, and applications. Centrifuge: Introduction, working principle, construction, merits, demerits, and applications. pH-meter: Introduction, working principle, construction, merits, demerits, and applications.	**10**
IV	**Characterization Techniques-I:** XRD: Introduction, working principle, merits, demerits, and applications.	**10**

	TEM: Introduction, working principle, merits, demerits, and applications. Raman: Introduction, working principle, merits, demerits, and applications.	
V	**Characterization Techniques-I:** DLS: Introduction, working principle, merits, demerits, and applications. SEM: Introduction, working principle, merits, demerits, and applications. Electro-spin: Introduction, working principle, merits, demerits, and applications.	**10**

SEMESTER-III

MPH-201: Advanced Condensed Matter Physics
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
Advanced knowledge of condensed matter physics and introduction of various fundamental concepts of condensed matter physics and materials science.

COURSE OUTCOMES:
CO1: Understanding of symmetry in crystals and phase transitions.
CO2: Understand waves in periodic structures, vibrations of crystal lattices, free electron theory.
CO3: Understand band structure, optical, transport, dielectric and magnetic properties of metals,
CO4: Able to differentiate semiconductors, insulators, and superconductors based on their properties.

Unit	Contents	Lectures
I	Dielectric Properties of Materials: Polarization mechanisms, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity.	**10**
II	Magnetism: Dia- and para-magnetism in materials, Pauli paramagnetic, Exchange interaction. Heisenberg Hamiltonian - mean field theory; Ferro-, ferri- and antiferromagnetic; spin waves, Bloch $T^{3/2}$ law.	**10**
III	Optical Processes and Excitons: Optical reflectance (Kramers- Kronig relations, electronic interbond transitions); Excitons, Raman effect in crystals (Brillouin scattering, Polariton scattering), Electron spectroscopy with X-rays.	**11**
IV	Superconductivity: Experimental Survey; Basic phenomenology; BCS pairing mechanism and nature of BCS ground state; Flux quantization; Vortex state of Type II superconductors; Tunneling Experiments; High T_c superconductors.	**11**

V	Disordered Solids: Basic concepts in point defects and dislocations; Non-crystalline solids: diffraction pattern, glasses, amorphous semiconductors and ferromagnets, heat capacity and thermal conductivity of amorphous solids, nanostructures – short expose; Quasicrystals.	**10**

REFERENCE BOOKS:

1. Introduction to Solid State Physics : C Kittel, Wiley, New York, 2005.
2. Quantum Theory of Solids : C Kittel, Wiley New York, 1987.
3. Principles of the Theory of Solids : J Ziman, Cambridge University Press, 1972.
4. Solid State Physics : H Ibach, H Luth, Springer, Berlin, 3rd ed., 2002.
5. A Quantum Approach to Solids : PL Taylor, Prentice-Hall, Englewood Cliffs, 1970.
6. Intermediate Quantum Theory of Solids : AOE Animalu, East-West Press, New Delhi,1991.
7. Solid State Physics : Ashcroft, Mermin, Reinhert & Winston, Berlin, 1976.

MPH-203: Nuclear and Particle Physics
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
The objective of the course is to familiarize the students to the basic aspects of nuclear and particle physics like static properties of nuclei, radioactive decays, nuclear forces, neutron physics, nuclear reactions the invariance principles and conservation laws.

COURSE OUTCOMES:

CO1: Understand the fundamental principles and concepts governing classical nuclear and particle physics and have a working knowledge of their application to real-life problems,

CO2: The students should be well versed by the end of the course by the basic building blocks of nature and the four fundamental interactions.

CO3: Students will get good theoretical basis of nuclear fission, nuclear fusion, and energy production in stars

CO4: Understanding of elements of Quantization

Unit	Contents	Lectures
I	**Nuclear Masses and Nucleon-Nucleon Interaction:** Analysis of nuclear masses, nuclear mass formula, stability of nuclei, beta decay and double beta decay. Properties of nuclear states: quantum numbers, angular momentum. Parity. Isotopic spin (isobaric spin, isospin), deuteron problem. Nucleon-Nucleon Interaction: Exchange forces and tensor forces, Meson theory of nuclear forces, Nucleon-Nucleon scattering, Spin dependences of nuclear forces, Effective range theory, Symmetry and nuclear force, Isospin invariance and operator general form of the nuclear potential, Yukawa theory of nuclear interaction.	**11**
II	**Nuclear Structure:** The Nuclear Shell, Shell Model Potential and Magic Numbers, Spin-Orbit couplings, Valence Nucleons and Ground State Spin of Nuclei, collective structure of Odd-A nuclei, The Nuclear Collective Model:	**10**

	Nuclear Collective Vibrations, Nuclear Collective Rotation, Single-particle motion in a deformed potential.	
III	**Nuclear Reaction:** Types of nuclear reactions, wave function and scattered waves, differential cross-sections, coupled equations and scattered potential, partial waves, total differential cross-sections, and Optical theorem. Optical Potential: average interaction potential for nucleons, energy dependence of potential, Compound nucleus formation and direct reactions, Compound resonances, Berit-Wigner formula, Inverse reactions (Reciprocity Theorem).	**10**
IV	**Classification of fundamental forces**. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons, and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.	**10**
V	**Elements of Quantization and Feynman rules.** Standard Model of Particle Physics: SU(3) x SU(2) x U(1) gauge theory, Coupling to Higgs and Matter fields of 3 generations. Gauge boson and fermion mass generation via spontaneous symmetry breaking, CKM matrix. QCD and quark model: Asymptotic freedom and Infrared slavery, confinement hypothesis. Approximate flavor symmetries of the QCD Lagrangian: Chiral symmetry and it's breaking. Classification of hadrons by flavor symmetry : SU(2) and SU(3) multiplets of Mesons and Baryons.	**11**

REFERENCE BOOKS:

1. C. N. Banwell, Elaine M. McCash; Fundamental of molecular spectroscopy, McGraw- Hill.
2. C. A. Coulson, R. McWeeny,Coulson's Valence, Oxford University Press.
3. L.D. Landau and E.M. Lifshitz, Quantum Mechanics.
4. M. Karplus and R.N. Porter,Atoms and Molecules: An Introduction for Students of Physical Chemistry.
5. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics.
6. Elementary Particles: IS Hughes, Cambridge University, 3rd ed., 1991.

POs COs	PO1	PO2	PO3	PO4	PSO1	PSO2	PSO3	PSO4
CO1	2	3	1	1	2	2	1	1
CO2	3	3	1	-	1	2	1	-
CO3	1	3	-	1	1	2	2	2
CO4	2	3	-	1	2	1	-	-

MPH-205: Material Science (F)
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

The objective of the course is to familiarize the students to the basic aspects of nuclear and particle physics like static properties of nuclei, radioactive decays, nuclear forces, neutron physics, nuclear reactions the invariance principles and conservation laws.

COURSE OUTCOMES:

CO1: Many new and exotic properties are possible to be developed in these materials and therefore, one can think of several exotic applications.

CO2: Ceramics can be fabricated with controlled pores size and porosity particularly for different types of separation technologies.

CO3: Understanding of superconductivity.

CO4: Understanding of different characterization techniques.

Unit	Contents	Lectures
I	Introduction to material science, Crystalline Structure, Crystal Defects and Non-crystalline structure, Diffusion, Mechanical Behavior, Thermal Behavior, Failure Analysis and Prevention, Phase Diagrams, Heat	**12**

	Treatment, Phase Transformations, Structural Materials- Metals, Ceramics and Glasses, Polymers and Composites, Electrical and Magnetic Properties, Semiconductors, Superconductors, Nanomaterials.	
II	Magnetism and Superconductivity, Demagnetization factor, Anti-ferromagnetism, Neutron diffraction, Magnetism in Rare Earths and Antiferromagnetic Alloys, Helimagnetism, Ferrimagnetism, Spin Glasses, Magnetotstriction, Domains and magnetization process, Single Domain Particles, Coercivity in fine particles, Superparamagnetism, Spintronics, Magnetoresistance, Applications.	**11**
III	Type-I Superconductivity, London theory, Specific Heat and Thermal Conductivity, Intermediate State, Measurements of Critical currents and Magnetic Properties, Critical State Models, Ginzberg-Landau and BCS Theory, Josephson effects, SQUIDs, Type-II Superconductivity; Pinning of Vortices, High Temperature Superconductors, Flux Flow, Flux Creep, Fluctuation effects, Levitation and Electrical Power Applications of HTSC.,	**11**
IV	Materials Characterization Techniques, Principles of X-ray Photometry Spectroscope (XPS) and Anger electron Spectroscopy (AES). Scanning Tunneling Microscopy (STM): Working principle, Instrumentation, Atomic Force Microscopy (	**9**
V	AFM): Introduction, Working Principal Instrumentation Modes of operation, Difference between STM and AFM, lattice planes and Bragg's law, X-ray diffraction (XRD), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy, Inferred (IR) spectroscopy, Ultraviolet (UV) and visible spectroscopy. Mössbauer Spectroscopy.	**9**

REFERENCE BOOKS:

1. Introduction to Solid State Physics: C Kittel, Wiley, 6th ed.
2. Solid State Physics: NW Ashcroft, N D Mermin, H R W International Edition, 1976.
3. Physics of Solids: C A Wert, R M Thomson, McGraw Hill.
4. Materials science and Engineering: William D Callister, Jr Callister's, Wiley India (P) Ltd.
5. Handbook of Advanced Ceramics Vol. I & II: S Somiya et al.

MPH-207(I): Advanced Electronics
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

The objective of the course is to give detailed knowledge of the modulation and demodulation processes. Amplitude, frequency, and phase modulation is described in detail. The modulation techniques-PAM, PPM, PWM, PCM and delta modulation will be studied in detail.

COURSE OUTCOMES:

CO1: Understanding of principle of Radar, Operating Characteristics of Radar System, Radar Antennas.

CO2: Understand the modulation process and its types.

CO3: Understand Practical Transmitting and Receiving Antennas- the antenna action.

CO4: Understand the different types of Antennas.

Unit	Contents	Lectures

I	**Integrated Circuit Fabrication:** Integrated-Circuit Technology, Advantages and limitations of Integrated Circuits, Basic Monolithic Integrated Circuits, Epitaxial Growth, Masking and Etching, Diffusion of Impurities: Integrated Capacitors and Inductors, Large-Scale and Medium-Scale Integration, Metal-Semiconductor Contact	**12**
II	**Modulation and Demodulation:** Definition, Amplitude modulation, Methods of Amplitude Modulation, Frequency Modulation, Phase Modulation, Pulse Modulation Systems- PAM, PWM, PPM, PCM, Delta Modulation, Principle of AM Detection, Frequency Demodulation.	**11**
III	**Radar:** Principle of Radar, Basic arrangement of Radar System, Azimuth and Range Measurement, Operating Characteristic of Radar System, Radar Antennas, Duplexer, Radar Receiver, Uses of Radar.	**11**
IV	**Antennas-I:** Antenna Action, Short Electric Doublet, Radiation from a Current Element, Thin Linear Antenna, Effect of Ground: Image Antenna, Short Vertical Grounded Antenna, Total Effective resistance, and Efficiency of an Antenna.	**9**
V	**Antennas-II:** Yagi Antenna, Loop Antenna, Parabolic Reflectors, Antenna measurements, Broadband antenna principles, Practical Transmitting Antennas, Receiving Antennas, Difference in Receiving and Transmitting Antennas.	**9**

REFERENCE BOOKS:

1. Integrated Electronics: Analog and Digital Circuits and Systems, Jacob Millman and Christos C. Halkias, Tata McGraw-Hill.
2. Networks, Lines, and Fields by John D. Ryder, Prentice Hall India.
3. Handbook of Electronics, Gupta & Kumar, Pragati Prakashan.

MPH-207(II): Integrated Circuit Fabrication
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
This course gives a comprehensive view of the Integrated Circuit Fabrication and Technology. A detailed description of the crystal growth process is discussed.
COURSE OUTCOMES:
CO1: Understanding of ion implantations and
CO2: Learn the different film deposition technique.
CO3: Understand the standard digital ICs.
CO4: Understand the logic circuits.

Unit	Contents	Lectures

I	Era of Integrated Circuit: Introduction to Monolithic Integrated Circuit Technology, Bipolar & MOS IC, Film IC. Crystal Growth: Silicon wafer Preparation & characterization, Oxidation: Thermal oxidation, Oxide thickness measurement, Oxidation system.	**11**
II	Ion implantation techniques, dopant profiles, apparatus used, Exitaxy: Eepitaxial growth of Si.	**11**
III	apparatus for epitaxy, Photolithography techniques for pattern transfer, Mask making, photo resist & Etching techniques.	**10**
IV	Film Deposition: Vacuum deposition & Sputtering apparatus, CVD Processes and its applications in IC Lab, Metallization	**10**
V	Standard Digital ICs: Combinational and Sequential MOS Logic Circuits, Design of standard Cells for LSI, VLSI Circuits. Semiconductor Memories.	**10**

REFERENCE BOOKS:

1. S.M. Sze (Ed.) / VLSI Technology / M Hill. 1988.
2. Basic VLSI Design by D.A. Pucknell & Eshraghian (PHI).
3. Modern VLSI Design Systems on Silicon by Wayne Wolf (Pearson Pub).
4. Introduction to Digital Microelectronics Circuits by K. Gopalan (TMH).

MPH-207(III): Accelerator Physics
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

Focus of this course is to introduce the students with the fundamentals of accelerator physics. This course will also focus on the details of the different types of the accelerators.

COURSE OUTCOMES:

CO1: Understand Charged Particle dynamics.
CO2: Understand of Electrostatic accelerators and Circular accelerators.
CO3: Understand the different accelerators.
CO4: Understand the basics of Synchrotron radiation sources.

Unit	Contents	Lectures
I	Charged Particle dynamics – non-relativistic and relativistic formulas, Electric and Magnetic fields, modifications of fields by materials, Particle motion in electric and magnetic fields, Beam transport system.	**8**
II	Ion sources: Production of heavy negative ions, RF ion source, SNICS, charge exchange canal, Duoplasmatron ion source, heavy – ion stripping using Carbon foil and gas strippers.	**8**
III	Electrostatic accelerators: Electrostatic generators, charging system, insulating column, high voltage multiplier and rectifier system, voltage measurements, Van-de-Graff accelerator, Trandem electrostatic accelerator Pelletron, Trandetron. Radiofrequency accelerators – Linear accelerators – Resonance acceleration and phase stability, electron and proton linacs.	**8**
IV	Circular accelerators – Cyclotron, Frequency Modulated Synchrocyclotron, AVF Cyclotron, Alternating- gradient accelerators, Betatron, Proton synchrotron, colliding accelerators. Superconducting Accelerators, Various accelerator combinations, Radioactive ion beams, Polarized beams, Accelerators for Meson production	**10**
V	Synchrotron radiation sources – Electromagnetic radiation from relativistic electron beams, Synchrotrons radiation spectrum, Spatial distribution, beam divergence, Temporal and Spatially coherent synchrotron radiation, Spectral brightness, Insertion devices – bending magnet radiation, wavelength shifter, Wiggler magnet radiation, Undulator radiation.	**10**

REFERENCE BOOKS:

1. Accelerator Physics, S.Y. Lee, World Scientific.
2. An Introduction to the Physics of Particle Accelerators – Mario Conte and William W. MacKay, World Scientific.
3. Principles of charged particle Acceleration; Stanley Humphries, John Willey & Sons.
4. Particle Accelerators, M.S. Livingston and J.P. Blewel, McGraw- Hill Book Press.
5. Handbook of accelerator Physics and engineering, Alexander Wu Chao and Maury Tigner, World Scientific.
6. Theory of Resonance Linear Accelerators by I.M. Kapchenkey, Harwood Academic Publishers.

MPH-207(IV): Plasma Physics
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

The course would be a basic course in plasma physics with focus on techniques of plasma production and measurements, waves and instabilities, single particle motion in electric and magnetic fields, plasma confinement, and applications to medium.

COURSE OUTCOMES:

CO1: Understand the Debye line, dc conductivity, ac conductivity.
CO2: Understanding of Plasma production and measurements.

CO3: Understanding of Waves and instabilities.
CO4: Understand Plasma confinement and its application.

Unit	Contents	Lectures
I	**Basics of plasmas**: Plasma as a state of matter, Debye length, plasma frequency, collisions, dc conductivity, ac conductivity.	**10**
II	**Plasma production and measurements**: dc discharge, rf discharge, photoionization, tunnel ionization, avalanche breakdown, laser produced plasmas, Langmuir probe.	**10**
III	**Waves and instabilities**: Electromagnetic waves, Langmuir wave, ion acoustic wave, surface plasma wave, ionosphere propagation, two stream instability, Weibel instability.	**10**
IV	**Plasma confinement**: Single particle motion in a magnetic field, motion in magnetic and electric fields, motion in inhomogeneous and curved magnetic fields, magnetic moment invariance, mirror confinement, tokamak confinement.	**12**
V	**Applications**: Medium and short-wave communication, plasma processing of materials, laser ablation, laser driven fusion, magnetic fusion.	**10**

REFERENCE BOOKS:

1. Introduction to plasma physics and controlled fusion, F.F. Chen, Plenum Press.
2. Interaction of electromagnetic waves with electron beams and plasmas, C.S. Liu and V.K.
3. Tripathi, World Scientific.
4. Principles of Plasma Physics, N.A. Krall and A.W. Trivelpiece, Mc Graw Hill.

MPH-207(V): Science of Renewable Energy Sources
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
Introduction of the energy sources, energy conservation, solar energy, hydrogen energy, wave energy and ocean thermal energy.

COURSE OUTCOMES:
CO1: Understanding of energy sources.
CO2: Understanding of Solar energy.
CO3: Understanding of Hydrogen energy.

CO4: Understanding the renewable energy

Unit	Contents	Lectures
I	Introduction: Classification of Energy Sources, Production alternatives and reserves of energy sources in the world and in India; need of renewable energy sources, energy security and energy conservation, Energy and its environmental impacts, Distributed generation.	**10**
II	Solar Energy : Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, fundamentals of photovoltaic energy conversion. Direct and indirect transition semi-conductors, interrelationship between absorption coefficients and band gap re combination of carriers.	**10**
III	Types of solar cells, p-n junction solar cell, Transport equation, current density, open circuit voltage and short circuit current, description and principle of working of single crystal, polycrystalline and amorphous silicon solar cells, conversion efficiency. Elementary ideas of Tandem solar cells, solid-liquid junction solar cells and semiconductor-electrolyte junction solar cells. Principles of photoelectrochemical solar cells. Applications.	**13**
IV	Hydrogen Energy: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel in vehicles and electrical power generation, hydride batteries.	**11**
V	Other sources: Wind energy, wave energy, ocean thermal energy conversion (OTEC).	**8**

REFERENCE BOOKS:

1. Solar Energy : SP Sukhatme, Tata McGraw-Hill, New Delhi, 2008.
2. Solar Cell Devices : Fonash, Academic Press, New York, 2010.
3. Fundamentals of Solar Cells, Photovoltaic Solar Energy : Fahrenbruch, Bube, Springer, Berlin, 1983.
4. Photoelectrochemical Solar Cells : Chandra, New Age, New Delhi.

MPH-209(I): Advanced Nano Physics
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

To focus on the emerging techniques and ideas of nanophysics where the small size of systems plays a crucial role in determining their properties and behavior.

COURSE OUTCOMES:

CO1: Growth control of nanoparticles

CO2: Understanding the basic physics behaving imaging techniques

CO3: Synthesis of thin film techniques.
CO4: Applications of nano technology

Unit	Contents	Lectures
I	Specific Features of Nanoscale Growth – Introduction - Nucleation – Homogeneous and heterogeneous nucleation- Growth control of nanoparticles. Metallic and semiconducting nanoparticles.	**12**
II	X-ray diffraction (XRD), FTIR, Raman Spectroscopy, Electron microscopes: Scanning electron microscope (SEM) – transmission electron microscope (TEM); atomic force microscope (AFM) – scanning tunnelling microscope (STM), Nuclear Magnetic Resonance (NMR).	**14**
III	Electrodeposition - Spray Pyrolysis - Flame Pyrolysis - Inert Gas Condensation Technique (IGCT) – Thermal evaporation – Pulsed Laser Deposition (PLD) – DC/RF Magnetron Sputtering - Molecular Beam Epitaxy (MBE)– Reverse Micelles and Micro emulsions - Combustion Method – Template Process - Chemical Vapor Deposition (CVD) – Metal Oxide Chemical Vapor Deposition (MOCVD).	**16**
IV	Materials for Use in Diagnostic and Therapeutic Applications. Nanotechnology for Defence Applications.	**6**
V	Hazards of Nanotechnology, Safety measures.	**4**

REFERENCE BOOKS:

1. Nanomaterials: Mechanics and Mechanisms, K. T. Ramesh, Springer 2009.
2. Nanoscale materials in chemistry, Edited by Kenneth J. Klabunde, John Wiley & Sons, 2009.
3. Nanoscale materials in chemistry, Edited by Kenneth J. Klabunde, John Wiley & Sons, 2001.
4. Nanoscopic materials; Size dependent phenomena, Emil Roduner, RSC publishing, 2006.

MPH-209(II): Fibre Optics & Non-linear optics
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

The main objective of this course is to familiarize students with a range of mathematical methods that are essential for solving advanced problems in theoretical Physics.

COURSE OUTCOMES:

CO1: Understand basic physics of Fibre optics.
CO2: Understand device fabrication techniques involving fibre optics.

CO3: Get to know about major applications.
CO4: Use of fibre optic sensors.

Unit	Contents	Lectures
I	Brief historical background of development of optical fibre, structure of optical fibre, numerical aperture, Step index and graded index fibre, single mode and multi-mode fibers.	**10**
II	Fabrication of optical fibers, silica, and polymer fibres, measurement of optical fibre parameters like refractive index profile, losses, dispersion effect in optical fibre.	**11**
III	Optical fibre for communication, modulation, EDFA, optical repeaters, fibre optic network, medical application: endoscopy.	**10**
IV	Fibre optic sensors: extrinsic and intrinsic sensors, Intensity modulated sensors, interferometric sensors, evanescent field sensors, chemical sensors, temperature, pressure, displacement sensors.	**10**
V	Optical Instrumentation: Measurement of Light: Sources & Detectors of optical radiation, Radiometry & Photometry; Optical Microscopes: Bright Field, Dark Field, Phase contrast, Fluorescence & Confocal microscopes; Telescopes, Ellipsometer, Refractometer.	**11**

REFERENCE BOOKS:

1. Introduction to fiber optics — AjoyGhatak and K. Thyagarajan
2. Optical Fiber communication — John M Senior
3. Fundamentals of Opto electronics — Clifford R. Pollock
4. Fiber optic communication — J. Palais.
5. Fundamentals of fibre optics in communication — B.P.Pal.

MPH-209(III): Advanced Nuclear & Particle Physics
(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:
The main objective of this course is to familiarize students with fundamentals of nuclear & high energy physics.

COURSE OUTCOMES:

CO1: Understanding basic idea universe in terms of nuclear physics.
CO2: Different processes involved in the supernovae.

CO3: Understanding different synthesis mechanism.
CO4: Understanding of basics of universe model.

Unit	Contents	Lectures
I	The observational basis of Nuclear Astrophysics, The importance of the four fundamental interactions, A Brief Description of the Observed Universe, The Origin of the Universe: The Hadron Era, the Lepton Era, The Radiation Era; the Stellar Era: Stellar Evolution: the Hertzsprung- Russel Diagram, Evolution of Stars: The Chemical Composition of the Observable Universe, Techniques for Abundance Determination: The Direct and Indirect Methods; The Abundances of Elements in the Universe, The main Sequence Stars.	**9**
II	Thermonuclear and Nuclear Reactions in Stellar Interiors; Nuclear Reactions: Generalities; Nuclear Reaction Rates; Hydrogen burning: The Proton Proton chain or PPI Chain, the Proton chains with a He Catalyst or PP II and PP III Chains; The CNO Cycle, Helium burning, Hydrostatic C,O and Si Burning Explosive Nucleosynthesis in stars.	**8**
III	Supernovae: the Fe Photodisintegration Mechanism, the C Detonation Mechanism, The Neutrino Transport Mechanism, Deceleration of the Central Pulsar, The Helium Flashes, the Novae Outbursts Explosions of Supermassive Stars, The Explosive Nucleosynthesis Explosive Burning in H and He burning Zones, Explosive Nucleosynthesis in C,O and Si burning Zones, Formation of the heavy Elements, Abundances of the Heavy Elements- Processes of Neutron Capture, Neutron Capture Reactions. The S-process, the main Neutron Sources for the S-process, The S-process Nucleosynthesis; the r-process; The p- process: Weak Interaction Mechanism Spallation Reactions, thermonuclear Reactions.	**13**
IV	Nucleosynthesis of Light Elements, the Abundances of Light Elements, the Spattation Reaction, Production of Li, Be, B by the galactic Cosmic Rays , Light Element Production in Stellar interiors and Supernovae explosions Big Bang Nucleosynthesis	**5**
V	The Basic Assumptions, the Standard Model of the Universe, The Cosmological principle and the expansion of the Universe, thermal Equilibrium, The Radiation Era, Freeze out, Cosmological Limits on Neutrino Mass, Primordial Nucleosynthesis, Helium Production, Bounds on the number of light neutrinos, Cosmological Bounds on Heavy Neutrinos, baryon Asymmetry of the Universe, The Baryon Number generation, the Cosmological Constant, The Inflationary Universe.	**7**

REFERENCE BOOKS:

1. An Introduction to Nuclear Astrophysics: Jean Audouze, SylvteVaudair.
2. The Early Universe: EW Kolb, MS Turner, Addision – Wesley.
3. An Introduction to Modern Stellar Astrophysics: DA Ostlie, BWCarroll,Addision Wesley, 2007.

MPH-209(IV): High Energy Physics

(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**15**
Credits:	:	**4**	ABQ	:	**30**
Contact hours	:	**52**	End-semester exam	:	**55**

OBJECTIVES:

The main objective of this course is to familiarize students with advances in high energy physics.

COURSE OUTCOMES:

CO1: Understanding gauge theories of fundamental interactions.

CO2: Understanding the objectives of high energy physics.
CO3: Understanding of high energy particles.
CO4: Basic difference between different interactions.

Unit	Contents	Lectures
I	Basic objectives of high energy physics. High frequency devices (including generators and detectors). Brief overview of four fundamental interactions and their characteristics, elementary particles and their characteristics**.** Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Fitting techniques.	**8**
II	Static model (SU(3)) of quarks. Baryon and meson supermultiplets. Spin-flavor state functions of baryon deca-pulets, baryon octets and meson nonets. Color wave functions. Magnetic moments of baryons. Principles of discoveries of heavy flavors: Charm, bottom and top. Summary of quantum numbers of all quark flavors. Vector mesons and their decays. Zweig rule.	**10**
III	Gauge theories of fundamental interactions. Internal symmetries. Global and local gauge invariances. U(1) and SU(3)symmetries. Comparison between Quantum Electrodynamics and Quantum Chromodynamics. Running coupling constants (derivations not required). Ultraviolet breakdown. Asymptotic freedom. Infrared slavery.	**10**
IV	High energy electron-proton scattering. Bjorken variable. Elastic, deep-inelastic régimes. Derivation of inclusive scattering cross section in terms of structure functions. Bjorken scaling. Scaling violation. Concepts of Mandelstam variables. Compton scattering and gluon emission scattering amplitudes and cross-sections in terms of Mandelstam variables. Altarelli-Parisi evolution equation.	**10**
V	Weak interaction. Analogy with electromagnetic interaction. Four-fermion point interaction of Fermi. Weak interaction amplitude in terms of bilinear covariants. Parity violation. T-θ paradox, Wu's experiment. Correlation data. V-A form of weak interaction amplitude. Parity violations in Λ0, K0 decays. Strangeness oscillation. Regeneration phenomenon. CP violation in K0 decay. CPT theorem (statement only). Strangeness-conserving and strangeness-violating weak interactions. Cabbibo theory.	**14**

REFERENCE BOOKS:

1. Introduction to High Energy Physics – D. H. Perkins, Addison Wesley, Reading, Mass
2. Quarks and Leptons: An Introductory Course in Modern Particle Physics – F. Halzen and A.D.Martin, John Wiley & Sons
3. The ideas of Particle Physics: An introduction for Scientists - G.D.Coughlan, J.E.Dodd and B.M.Gripaios, Cambridge University Press
4. Facts and Mysteries in Elementary Particle Physics – MartinusVeltman, World Scientific

MPH-251: Computational Physics Laboratory
(Semester III)

L+T+P	:	**0+0+3**	Viva-voce + Continuous lab performance	:	**40**
Credits:	:	**2**			
Contact hours	:	**26**	Viva-voce + Written exam + Practical record file	:	**60**

OBJECTIVES:

The objective of the course Computational Physics Laboratory is to expose the students of M.Sc. class to theoretical study by using Computational Physics techniques.

COURSE OUTCOMES:

S. No.	Practical Description
1.	Find standard deviation, mean, variance, moments etc. of at least 25 entries.
2.	Choose a set of 10 values and find the least squared fitted curve.
3.	Generation of waves on superposition like stationary waves and beats
4.	Fourier analysis of square waves.
5.	To find the roots of quadratic equations.
6.	Wave packet and uncertainty principle
7.	Find y for a given x by fitting a set of 9 values with the help of cubic spline fitting technique.
8.	Find first order derivative at given x for a set of 10 values with the help of Lagrange interpolation.
9.	To generate random numbers between (i) 1 and 0, (ii) 1 and 100.
10.	Perform numerical integration on 1-D function using Simpson and Weddle rules.
11.	To find determinant of a matrix - its eigenvalues and eigenvectors
12.	Use Monte Carlo techniques to simulate phenomenon of Nuclear Radioactivity. Modify your program to a case when the daughter nuclei are also unstable.
13.	Statistical and error analysis of (a) given data (b) error estimation in computation.
14.	Operations on a matrix "inversion"
15.	Operations on a matrix "solution of simultaneous equations"
16.	Plotting and interpolation of a function.
17.	Operations on a matrix "diagonalization (3x3 matrix)"
18.	Finding the value of Pi using monte carlo method
19.	Numerical differentiation and integration of simple functions.

REFERENCE BOOKS:

1. Numerical Mathematical Analysis: JB Scarborough, Oxford & IBH Book Co., 6th ed., 1979.
2. A first course in Computational Physics: PL DeVries, Wiley, 2nd ed., 2011.
3. Computer Applications in Physics: S Chandra, Narosa, 2nd ed., 2005.
4. Computational Physics: RC Verma, PK Ahluwalia, KC Sharma, New Age, 2000.
5. Object Oriented Programming with C++: Balagurusamy, Tata Mc Graw Hill, 4thed., 2008.

MPH-253: Synopsis Seminar
(Semester III)

L+T+P	:	**0+0+2**	Write up	:	**25**
Credits:	:	**1**	Viva-voce	:	**25**
Contact hours	:	**13**	Presentation	:	**50**

Description
Students are required to submit a synopsis on the allotted topic and must make a presentation in front of advisory committee and M.Sc. Students. Students are expected to provide latest facts and updated information by consulting latest editions of textbooks, reference books, monographs, and peer-reviewed national & international research journals.

S.No.	Course details
1.	Synopsis writing
2.	Synopsis seminar
3.	Approval of synopsis by research committee
4.	Research work by taking 13 credit hours

MPH-255: Dissertation

(Semester III)

L+T+P	:	**0+0+8**
Credits:	:	**4**
Contact hours	:	**52**

Description
Students are required to work on the allotted topic and must make a presentation in front of advisory committee and M.Sc. Students. Students are expected to provide latest facts and updated information by consulting latest editions of textbooks, reference books, monographs, and peer-reviewed national & international research journals.

S.No.	Course details
1.	Research work
2.	Seminar
3.	Evaluation by Research committee
4.	Research work by taking 52 credit hours

SEMESTER-IV

MPH-252: Dissertation
(Semester IV)

L+T+P	:	**0+0+40**
Credits:	:	**20**
Contact hours	:	**260**

Description
Semester IV is only for dissertation work. There will be no theory or practical courses in this semester. Dissertation will carry marks for continuous assessment, dissertation write-up, its presentation and viva-voce. This will be evaluated at the end of fourth semester. Students will work on a research topic assigned to him/her by their supervisor/mentor with a purpose to develop a collective approach to study, analyze and solve the problem. Students are required to collect, analyze the data, and submit their dissertation at the end of the semester.

S.No.	Course details
1.	Research work
2.	Seminar
3.	Evaluation by Research committee
4.	Thesis writing
5.	Research work by taking 260 credit hours