M.Sc. Physics

Scheme & Syllabus (M.Sc.-Physics)

Semester 1

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	External	Internal	Total	
MPH21-101	Mathematical Physics-I	4	1	0	100	50	150	5
MPH21-102	Classical Mechanics	4	1	0	100	50	150	5
MPH21-103	Statistical Mechanics	4	1	0	100	50	150	5
MPH21-104	Semiconductors and Electronic Devices	4	1	0	100	50	150	5
MPH21-105	Quantum Mechanics-I	4	1	0	100	50	150	5
MPH21-106	Physics Lab-I	0	0	6	100	50	150	3
Total		20	5	6	600	300	900	28

Semester 2

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	External	Internal	Total	
MPH21-201	Mathematical Physics-II	4	1	0	100	50	150	5
MPH21-202	Condensed Matter Physics-1	4	1	0	100	50	150	5
MPH21-203	Atomic &Molecular Physics	4	1	0	100	50	150	5
MPH21-204	Digital Electronics	4	1	0	100	50	150	5
MPH21-205	Numerical Analysis and Computer Programming	4	0	4	100	50	150	6
MPH21-206	Physics Lab-II	0	0	6	100	50	150	3
Total		20	4	10	600	300	900	29

Scheme & Syllabus (M.Sc.-Physics)

Semester 3

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	External	Internal	Total	
MPH21-301	Quantum Mechanics-II	4	1	0	100	50	150	5
MPH21-302	Condensed Matter Physics -II	4	1	0	100	50	150	5
MPH21-303	Nuclear Physics	4	1	0	100	50	150	5
MPH21-304	Classical Electrodynamics	4	1	0	100	50	150	5
MPH21-305	Physics Lab-III	0	0	6	100	50	150	3
Total		16	4	6	500	250	750	23

Semester 4

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	External	Internal	Total	
MPH21-401	Physics of Nanomaterials	4	1	0	100	50	150	5
MPH21-402	Synthesis and Characterization of Materials	4	1	0	100	50	150	5
MPH21-403	Physics Lab-IV	0	0	6	100	50	150	3
And any **TWO** of the following subjects								
MPH21-404	Radiation Physics	4	1	0	100	50	150	5
MPH21-405	Advanced Statistical Mechanics	4	1	0	100	50	150	5
MPH21-406	Reactor Physics	4	1	0	100	50	150	5
MPH21-407	Fibre Optics and Non-linear Optics	4	1	0	100	50	150	5
Total		16	4	6	500	250	750	23

MPH21-101 Mathematical Physics-I

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Elements of complex analysis: Introduction, Laurent series-poles, residues and evaluation of integrals; Cauchy-Riemann conditions, Cauchyôs Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals.

15 lectures

2. Differential Equations: Linear differential equations with constant coefficients, Cauchyôs homogeneous linear equation, Use of Partial differential equations in physics problems, separation of variables.

15 lectures

3. Special Functions: Dirac delta function, Gamma function, Beta function. Bessel function of first and second kind, Generating function, integral representation and recurrence relations for Besselôs functions of first kind, orthogonality. Legendre functions: generating function, recurrence relations and special properties, orthogonality, Associated parity, Hermite functions, Laguerre functions.

15 lectures

Suggested Books

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press, San Diego).
2. Mathematical Physics: P.K. Chattopadhyay (Wiley Eastern, New Delhi).
3. Mathematical Physics : A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan,India, Delhi).
4. Mathematical Methods in the Physical Sciences ï M.L. Boas (Wiley, New York).
5. Special Functions : E.D. Rainville (MacMillan, New York).
6. Mathematical Methods for Physics and Engineering : K.F.Riley, M.P.Hobson and S.J. Bence (Cambridge University Press, Cambridge).
7. Advanced Mathematical Physics by Erwin Kreyszig

MPH21-102 Classical Mechanics

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1.**Lagrangian Formulation:** Mechanics of a system of particles; constraints of motion, generalized coordinates, DôAlembertôs Principle and Lagrangeôs velocity- dependent forces and the dissipation function, Applications of Lagrangian formulation**.** **10** lectures

2. **Hamilton's Principles:** Calculus of variations, Hamiltonôs principle, Lagrangeôs equation from Hamiltonôs principle, symmetry properties of space and time and conservation theorems.

7 lectures

3.**Rigid Body Motion:** Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Eulerôs theorem, 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. **10 lectures**

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

5. **Hamilton's Equations:** Legendre Transformation, Hamiltonôs equations of motion, Cyclic co-ordinates, Hamiltonôs equations from variation principle, Principle of least action.

5 lectures

6. **Canonical Transformation and Hamilton-Jacobi Theory:** Canonical transformation and its examples, Poissonôs brackets, Equations of motion, Angular momentum, Poissonôs Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton-Jacobi equations for principal and characteristic functions**.** **8 lectures**

Suggested Books

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

MPH21-103 Statistical Mechanics

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1**. Review of Thermodynamics**: Laws of thermodynamics and their consequences; Thermodynamic potentials, Maxwell relations; Chemical potentials, Phase equilibrium.

7 lectures

2. **The Statistical Basis of Thermodynamics:** The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution.

8 lectures

3. Ensemble Theory: Phase space and Liouville's theorem, the micro canonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble, statistics of paramagnetism; The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations. **15 lectures**

4**. Quantum Statistics**: Quantum-mechanical ensemble theory: Density matrix, simple applications of density matrix. Symmetric and Antisymmetric Wavefunctions. Microcanonical ensemble of ideal Bose, Fermi and Boltzmann gases. Statistics of the occupation numbers

7 lectures

5. Ideal Bose and Fermi Systems: Ideal Bose systems: basic concepts and thermodynamic behavior of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems: thermodynamic behavior of an ideal Fermi gas, discussion of heat capacity of a free electron gas at low temperatures, Pauli paramagnetism**.** **8 lectures**

Suggested books:

1. Statistical Mechanics (2nd edition): R.K. Pathria (Butterworth-Heinemann, Oxford).
2. Statistical Mechanics: K. Huang (Wiley Eastern, New Delhi).
3. Statistical Mechanics: B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi).
4. Elementary Statistical Physics: C. Kittel (Wiley, New York).
5. Statistical Mechanics: S.K. Sinha (Tata McGraw Hill, New Delhi)
6. Statistical Physics by E S Rajagopal

MPH21-104 Semiconductors and Electronic Devices

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Semiconductors and Junction diodes
Introduction to semiconductors, Drift and diffusion of carriers, Fermi level, Direct and indirect semiconductors, Photoconductors, Capacitance of p-n junctions, Varactors, Tunnel diode, Light emitting diodes, Metal-semiconductor junctions; Ohmic and rectifying contacts, FET as switch and amplifier, MOSFET, Enhancement and depletion mode. Introduction to CMOS, CMOS Capabilities and Limitations and CMOS Transistors as logic gates (*viz*. NOT, NAND and NOR etc.) **13 lectures**

2. Circuit Analysis Theorems
Sources of electrical power, Voltage and Current sources, equivalence between voltage and current source, Thevenin and Norton theorems, maximum power transfer theorem (statement and proof), Delta star (Y) transformations. **7 lectures**

3. Operational Amplifier: Operational amplifier, open loop op-amp, differential amplifier, inverting amplifier, non- inverting amplifier, voltage follower, difference and common mode gain, common mode rejection ratio. Input bias current, input offset current, input offset voltage, frequency response, slew rate, concept of feedback, Stability of operational amplifier.
Operational Amplifier as: Summing, integrator and differential, Logarithmic and anti-logarithmic amplifiers, Current-to-voltage and Voltage-to-current converter, Comparators; Schmitt trigger and square wave generator. Sinusoidal Oscillators: Phase Shift, Wein bridge.
15 lectures

4. Switching circuits and Power electronics
Construction and Working of Silicon controlled rectifier (SCR) Diac, Triac, Unijunction Transistor (UJT) and their applications, Transistor multivibrators: astable, monostable and bistable multivibrators.
10 lectures

Suggested Books:
1. Semiconductor Devices - Physics and Technology by S.M. Sze(Wiley)
2. Linear and Non-linear Circuits by Chua, Desoer and Kuh(Tata McGraw)
3. Integrated Electronics by Millman and Halkias(Tata McGraw Hill)
4. Electronic devices and Circuit theory by Boylestad and Nashelsky(Preutice Hall).
5. OPAMPS and Linear Integrateed circuits by Ramakant A Gayakwad (Prentice Hall).
6. Electronic Principles by A.P. Malvino(Tata McGraw, New Delhi).
7. Electronic Communication Systems : Kennedy and Davis (Tata McGraw Hill).
8. Semiconductor Physics by Maan Singh.
9. Semiconductor Physics by Choudhary
10. Principles of Electronics: V.K. Mehta and Shalu Mehta, S. Chand & Co. Ltd. New Delhi.

MPH21-105 Quantum Mechanics-I

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. **Introduction to Wave Mechanics and Quantum Behaviour**
Wave equation and its general solution, Quantisation in wave mechanics and bound waves, the two-slit diffraction experiment, Particle/wave duality, The classical/quantum description of the state of a particle, the wave function and its interpretation, The cordinate and momentum representation of the quantum state, The wave equation in momentum space, The uncertainty principle. **10 lectures**

2. **General Formalism of Quantum Theory**
The principle of superposition, Formation of wave-packet, Fourier analysis of wave-packet and its group velocity, Gaussian wave packet, probability current density, equation of continuity, Basic postulates of Quantum Mechanics, Probabilities in momentum and coordinate space, operator representation of dynamical variables, Hermitian operators and properties of eigenvalues and eigenfunctions of hermitian operators, expectation values and indeterminacies, Ehrenfest's theorem, Eigen value equation, Eigen value and eigen function,Ket Bra notation and Dirac delta function. **10 lectures**

3. **Schrödinger equation and its applications**
Hamiltonian operator andenergy eigenvalue equation, Time independent and time dependent schrodinger equation, particle in one dimensional box, the one dimensional simple harmonic oscillator, the hydrogen atom. 5 **lectures**

4. **Angular Momentum in Quantum Mechanics**
Compatible and incompatible variables, commuting observables and simultaneous measurements, The angular momentum operators, commutation relations of angular momentum operators, Orbital angular momentum eigenfunctions and eigenvalues, the parity operator, The ladder operator method for the angular momentum spectrum, Electron spin, Pauli's spin matrices and their properties, Addition of two angular Momenta. **10 lectures**

5**. Matrix Formulation**
Alternative to Schrödinger's wave mechanics, the representation of the state of a particle in a discrete basis, the matrix representation for dynamical variables, eigenvalue equations in the matrix formulation, a spin half particle in a magnetic field. **10 lectures**

Suggested Books:

1 E. Merzbacher, Quantum Mechanics
2 R.P. Feynman, Feynman Lectures on Physics
3 Sara M. McMurry, Quantum Mechanics
4 L.I. Schiff, QuantumMechanics
5 J J. Sakurai,Modern Quantum Mechanics

MPH21-106 Physics Lab-I

Internal Marks: 50 **L T P**
External Marks: 100 **0 0 6**
Total Marks: 150

The aim and objective of the courses on Physics Laboratory I is to expose the students of M.Sc. to the experimental techniques in general Physics, analog electronics, and semiconductor devices so that they can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments wherever necessary.

Note : Students are expected to perform at least 10 experiments in one semester.

1. To trace I-V characteristic curves of diodes and transistors on a CRO, and learn their uses in electronic circuits.

2. Study of Zener regulator as voltage regulator.

3. To plot the input and output characteristics of CE configuration.

4. To Study the D C characteristics and applications of DIAC.

5. To study the D C characteristics and applications of SCR.

6. To study the D C characteristics and applications of TRIAC.

7. Investigation of the D C characteristics and applications of UJT.

8. Investigation of the D C characteristics of MOSFET.

9. Study of bi-stable, mono-stable and astable, multivibrators.

10. Study of Op-Amps and their applications such as an amplifier (inverting, non-inverting), scalar, summer, differentiator and integrator.

11. To determine the energy gap and resistivity of the semiconductor using four probe method.

12. To study temperature dependence of conductivity of a given semiconductor crystal using four-probe method and Vander Paw method.

MPH21-201: Mathematical Physics - II

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. **Fourier Analysis:** Fourier series of periodic functions, even and odd functions, half range expansions and different wave forms, complex form of Fourier series and practical harmonic analysis. Fourier transforms of various standard functions. **15 Lectures**

2. Laplace Analysis & Inverse Laplace Analysis: Laplace transforms of various standard functions, properties of Laplace transforms and inverse Laplace transforms. **10 Lectures**

3. **Group theory:** Definition of a group, multiplication table, conjugate elements and classes of groups, direct product Isomorphism, homomorphism, permutation group, definition of the three dimensional rotation groups. **10 Lectures**

4. Elementary Statistics: Introduction to probability theory, random variables, Binomial, Poisson and Normal distributions, Central limit theorem. **10 Lectures**

Suggested Books

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press,San Diego).
2. Mathematical Physics: P.K. Chattopadhyay (Wiley Eastern, New Delhi).
3. Mathematical Physics : A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan,India,Delhi).
4. Mathematical Methods in the Physical Sciences ï M.L. Boas (Wiley, New York).
5. Special Functions : E.D. Rainville (MacMillan, New York).
6. Mathematical Methods for Physics and Engineering : K.F.Riley, M.P.Hobson and S.J. Bence (Cambridge University Press, Cambridge).
7. Mathematical Physics: Satya Prakash (S. Chand & Sons)

MPH21-202 Condensed Matter Physics-1

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Crystal Structure

Crystals, Bravais lattice, symmetry operations and classification of Bravais lattices, Common crystal structures, Determination of crystal structure: X-ray diffraction, Braggôs law, qualitative idea of electron and neutron diffraction. Elastic strain and stress component. Elastic compliance and stiffness constants. Elastic constants of cubic crystals. Elastic waves in cubic crystals. **10 lectures**

2. Thermal properties of Crystal lattices

Specific heat, lattices heat capacity, classical, Einstein and Debye theories of specific heat, Bornôs modification of the Debye theory, Thermal expansion. **10 lectures**

3. Free Electron Theory of metals

Free electron gas model, Electrical conductivity of metals, Drift velocity and relaxation time, the Boltzmann transport equation. Drude and Lorentz theory, The Sommerfeld theory of conductivity, thermal conductivity, Widemann-Franz law, Hall effect. **10 lectures**

4. Magnetism

Classification of magnetic materials, the origin of permanent magnetic dipoles, diamagnetic susceptibility, classical theory of Para magnetism, Quantum theory of Para magnetism, Quenching of orbital angular momentum, cooling by adiabatic demagnetization. Paramagnetic susceptibility of conduction electrons, Ferromagnetism, the Weiss molecular field, the interaction of the Weiss field, Heisenberg exchange interaction, types of exchange interactions, Ferromagnetic domains, Antiferro, Ferrimagnetism: The two sub lattice model, Neel's theory of ferrimagnetisms. Superconductivity: Critical field, Meissner effect, Types of superconductors, specific heat, London equations, penetration depth, BCS Theory, Tunneling phenomena, Josephson effect and its applications, Introduction to high temperature superconductors.

15 lectures

Suggested Books:

1. C. Kittel, Introduction to Solid State Physics.
2. N.W. Ashcroft and N.D. Mermin, Solid State Physics.
3. J.M. Ziman, Principles of the Theory of Solids.
4. A.J. Dekker, Solid State Physics.
5. G. Burns, Solid State Physics.
6. M.P. Marder, Condensed Matter Physics.
7. B. D. Cullity, Elements of X-Ray Diffraction
8. L V Azaroff, Introduction to Solids R
9. R. L Sighal, Solid State Physics

MPH21-203 Atomic & Molecular Physics

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. One Electron Atom: Vector model of a one electron atom, Quantum states of an electron in an atom, Hydrogen atom spectrum, Spin-orbit coupling, Relativistic correction, Hydrogen fine structure, Spectroscopic terms, Hyperfine structure. **9 lectures**

2. Two valance Electron Atom: Vector model for two valance electrons atom, LS coupling, Pauli exclusion principle, Interaction energy for LS coupling, Lande interval rule, jj coupling, interaction energy for jj coupling.

8 lectures

3. Atom in Magnetic Field: Zeeman effect, Magnetic moment of a bound electron, Magnetic interaction energy in weak field. Paschen-Back effect, Magnetic interaction energy in strong field.

8 lectures

4. Atom in Electric Field: Stark effect, First order Stark effect in hydrogen. **5 lectures**

5. Molecular Spectroscopy: Rotational and vibrational spectra of diatomic molecule, Raman Spectra, Electronic spectra, Born-Oppenheimer approximation, Vibrational coarse structure, Franck-Condon principle, Rotational fine structure of electronic-vibration transitions.

10 lectures

6. Spin Resonance Spectroscopy: Electron spin resonance and nuclear magnetic resonance spectroscopy. **5 lectures**

Suggested Books:

1. White H. E., Introduction to Atomic Spectra, McGraw Hill (1934).
2. Banwell C. N. and McCash E. M., Fundamentals of molecular spectroscopy , Tata McGraw Hill (1994).

MPH21-204 Digital Electronics

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Number System and Binary Code: Binary, Octal and Hexadecimal Number System (Conversion, Addition & Subtractions). Signed and unsigned numbers, Binary Subtractions using 1's and 2's compliment, ASCII code, Excess 3 code, Grey code, BCD code and BCD additions. Parity, Error Detection codes, Hammings Error correction code.

8 lectures

2. Minimization of logic function: OR, AND,NOT,NOR,NAND,EX-OR, EX-NOR, Basic theorem of Boolean Algebra, Sum of Products and Product of Sums, canonical form, Minimization using K-map.

10 lectures

3. Combinational Circuits: Combinational circuit design, Encoders, decoders, Adders, Sub tractors and Code converters. Parity checker, seven segment display, Magnitude comparators. Multiplexers, De-multiplexer, Implementation of Combinational circuit using MUX.

12 lectures

4. Sequential Circuits: Introduction, flip flops, Clocked flip flops, SR, JK, D, T and edge triggered flip- flops. Excitation tables of Flip flops. Shift Registers, Type of Shift Registers, Counter, Counter types, counter design with state equation and state diagrams.

15 lectures

Suggested Books :

1. Digital Principles and Applications : Malvino and Leach (Tata McGraw Hill) (2010).
2. Modern Digital electronics, R. P. Jain (Tata McGraw-Hill, New Delhi) (2006).
3. Digital Computer Electronics : Albert P. Malvino, Jerald A Brown (Tata-McGraw Hill).
4. Microprocessor Architecture, Programming and Applications with 8085 : R.S. Gaonkar (Prentice Hall) (2002).
5. The 8051 Microcontroller and embedded Systems by M. Ali Mazidi, J.G. Mazidi and R.D.M. Mckinley (Pearson Education) (2009).
6. Integrated Electronics, J. Millman and C.C. Halkias (Tata McGraw-Hill, New Delhi) (2008)

MPH21-205 Numerical Analysis And Computer Programming

Internal Marks: 50 **L T P**
External Marks: 100 **4 0 4**
Total Marks: 150

1. **Methods of approximation and errors:** Truncation and round-off errors; Accuracy and precision. 2 **lectures**

2. **Roots of Equations**: Bisection method, False position method, Iteration methods (Newton-Raphson). Systems of linear algebraic equations: inversion and LU decomposition methods. Gauss elimination method. **5 lectures**

3. Curve fitting: Least squares regression, linear and nonlinear regressions. **5 lectures**

4. Interpolation Methods: interpolating polynomials. Newton's divided difference. **5 lectures**

5. Numerical differentiation and integration: Trapezoidal and Simpson's rules. **5 lectures**

6. Ordinary differential equations: Euler's method, Runge-Kutta methods. Boundary value and Eigenvalue problems. Partial differential equations: Numerical solution of Laplace's equation, Few applications. 8 **lectures**

7. Fourier approximation: Introduction, Discrete Fourier and Fast-Fourier Transforms.

5 lectures

8. Computer Programming: Some computer programs in suitable languages, based on above topics. **10 lectures**

Suggested Books:

1. Shastry, S.S., "Numerical Methods", Prentice Hall Inc., India, 1998.

2. Richard L. Burden and J. Douglas Faires, ñNumerical Analysisò, Brooks/Cole, Cengage Learning

3. Noble Ben, "Numerical Methods", New York International Publications, New York, 1964.

4. Numerical Analysis with Algorithms and Programming; Santanu Saha, CRC press, 2016

5. Buckingham R.A., "Numerical Methods", Sir Isaac Pitman Sons. Ltd., London, 1957.

6. Uri M. Ascher and Chen Greif, ñA first Course in Numerical Methodsò SIAM, 2011.

7. Bakhvalov, N .S., "Numerical Methods", Mir. Pub., Moscow, 1977.

8.Numerical recipes in C++ or Fortran

MPH21-206 Physics Lab-II

Internal Marks: 50 **L T P**
External Marks: 100 **0 0 6**
Total Marks: 150

The aim and objective of the courses on Physics Laboratory II is to expose the students of M.Sc. to the experimental techniques in digital electronics, condensed matter physics and spectroscopy, so that they can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments wherever necessary.

Note : Students are expected to perform at least 10 experiments in one semester.

1. To study the use of digital to analog and analog to digital converter.
2. To study logic gates and flip flop (JK, RS and D) circuits using on a bread-board. 14. 8085 microprocessor kit ï familiarization and introductory programming.
3. Study of Logic Gates: Truth-table verification of OR, AND, NOT, XOR, NAND and NOR gates;
4. Realization of OR, AND, NOT and XOR functions using universal gates.
5. Realization Half Adder / Full Adder using Logic gates.
6. Realization Half Subtractor / Full Subtractor using Logic gates
7. Design 4-Bit Binary-to-Gray & Gray-to-Binary Code Converter.
8. Design 4-Bit magnitude comparator using logic gates.Multiplexer: Truth-table verification and realization of Half adder and Full adder using MUX.
9. Demultiplexer: Truth-table verification and realization of Half subtractor and Full subtractor using DEMUX.
10. Flip Flops: Truth-table verification of RS, JK , D, JK Master Slave Flip Flops.12
11. Design MOD-7 Synchronous up-counter using JK/RS/D Flip Flops.
12. Shift Register: Study of shift right, SIPO, SISO, PIPO, PISO & Shift left operations using IC7495 chip.
13. The Hall coefficient for given semiconductor and study its temperature dependence.
14. To study the FM and PM transition in Ni through electrical resistivity measurements.
15. To trace hysteresis loop and calculate retentivity, coercivity and saturation magnetization.
16. Detrmination of crystal structure and lattice parameters using X-ray diffraction technique.
18. To determine the magnetic susceptibility of a material using Quink's method.
19. To find the wavelength of monochromatic light using Febry Perot interferometer.
20. To find the wavelength of sodium light using Michelson interferometer.
22. To find the grating element of the given grating using He-Ne laser light.
24. To verify the existance of Bohr's energy levels with Frank-Hertz experiment.
25. To determine the charge to mass ratio (e/m) of an electron with normal Zeeman Effect.
26. To determine the g-factor using ESR spectrometer.

MPH21-301 Quantum Mechanics-II

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. **Perturbation Theory** Time-independent perturbation theory, First order perturbations, Second order perturbations: anharmonic oscillator, Degenerate perturbation theory: spin-orbit coupling, the time dependent Schrodinger equatio, Resonant transition between two energy states, Time dependent perturbation theory, Transition rates and Fermi golden rule.

12 lectures

2. Relativistic Quantum Mechanics Basic notions of relativity and the Lorentz transformations, Klein Gordon equation, Lorentz transformation of spinors and the Dirac equation, The Dirac equation in the presence of an electromagnetic field and the magnetic moment. **11 lectures**

3. **Elements of Scattering Theory** Elastic scattering : elementary considerations on quantum theory of scattering in a given potential method of partial waves, the optical theorem, Born approximation, Low energy scattering and bound states, Scattering in a Coulomb field, scattering of identical particles and scattering of particles with spin, A brief overview of time dependent formulation of scattering. Inelastic collisions and the S matrix : a brief overview.

13 lectures

4. Systems of Identical Particles Classical vs. quantum descriptions, Brief introduction to identical particles in quantum mechanics, Permutation operators and manybody wavefunctions, Application to 2 -electron systems, Pauli exclusion principle, Bose Einstein and Fermi Dirac Statistics. **9 lectures**

Suggested Books :

1. Modern Quantum Mechnics: J.J. Sakurai-Pearson Educaton Pvt. Ltd., New Delhi, 2002.
2. Quantum Mechanics: L I Schiff-Tokyo Mc Graw Hill, 1968.
3. Feynmann lectures in Physics Vol. III-Addison Wesly, 1975.
4. Quantum Mechanics: Powel and Craseman-Narosa Pub. New Delhi, 1961.
5. Quantum Mechanics: Merzbacher-JohnWiley & Sons, New York, 197

MPH21-302 Condensed Matter Physics-II

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Defects and Diffusion in Solids:
Point defects: Impurities, Vacancies- Schottky and Frankel vacancies, Color centers, F-centres, Line defects (dislocations), Edge and screw dislocations, Berger Vector, Slip, Planar (stacking) Faults, Grain boundaries, Low angle grain boundaries, the Hydration energy of ions, Activation energy for formation of defects in ionic crystals, Diffusion in solids, Classification of diffusion process, Ficks law, Factor affecting diffusion and applications, Kirkendal law interpretation of diffusion in alkali halides. **15 lectures**

2. Dielectric Properties of Solids
Dielectrics and Ferroelectrics: Macroscopic field, The local field, Lorentz field. The Claussius-Mossotti relations, different contribution to polarization: dipolar, electronic and ionic polarisabilities, General properties of ferroelectric materials. The theories of ferroelectricity. **10 lectures**

3. Electronic Energy bands in Solids: Wave functions in periodic potential and Bloch theorem, Kronig-Penney Model, E vs. K relations, Motion of electron in one dimension according to band theory, Crystal momentum, Concept of effective mass and hole. Distinction between metals, insulators and semiconductors, Brillouin zones, density of states, overlapping of energy bands. **10 lectures**

4. Optical Properties of solids: Dielectric function of electron gas, plasma frequency Plasmons, Excitons, Photoconductivity, influence of traps, Luminescence: excitation and emission, Efficiency of a phosphor, Decay mechanisms, Thermo-luminescence and glow curves, Electroluminescence. **10 lectures**

Suggested Books:
1. C. Kittel, Introduction to Solid State Physics.
2. N.W. Ashcroft and N.D. Mermin, Solid State Physics.
3. J.M. Ziman, Principles of the Theory of Solids.
4. A.J. Dekker, Solid State Physics.
5. G. Burns, Solid State Physics.
6. M.P. Marder, Condensed Matter Physics.
7. B. D. Cullity, Elements of X-Ray Diffraction
8. L V Azaroff, Introduction to Solids
9. R.L. Singhal, Solid State Physics,

MPH21-303 Nuclear Physics

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Properties of Atomic Nucleus

Theories of nuclear composition (proton-electron, proton-neutron), Binding Energy, Semi-empirical Mass Formula for nuclear stability, Quantum numbers of nucleons, Quantum properties of nuclear states, nuclear angular momentum, Nuclear Magnetic dipole moment, Electric quadrupole moment, potential well, quantum statistics.

7 **Lectures**

2. Nuclear Interactions

Nuclear Forces: Two nuclear system, deuteron problem, proton-proton and proton-neutron scattering experiments at low energy, meson theory of nuclear forces, exchanges forces and tensor forces, effective range theory-spin dependence of nuclear forces-Charge independence and charge symmetry of nuclear forces-Isospin formalisim.

15 Lectures

3 Nuclear Models

Bohr-Wheeler theory of fission, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic-Applications of Shell model like Angular momenta and parities of nuclear ground states, Quantitative discussion and estimates of transition rates-magnetic moments and Schmidt lines, Collective model, Nuclear vibrations spectra and rotational spectra, applications.

15 Lectures

4. Nuclear Reactions

Direct and compound nuclear reaction mechanisms, cross sections in terms of partial wave amplitudes, Compound nucleus, scattering matrix, Reciprocity theorem, Breit Winger one level formula, Resonance scattering.

8 **Lectures**

Suggested Books:

1. Roy R.R. & Nigam B.P., Nuclear Physics, New Age International Ltd (2001).
2. Preston M. A. and Bhaduri R. K., Structure of Nucleus Addision-Welsey (2000).
3. Pal, M.K., Theory of Nuclear Structure, East-West Press Delhi (1983).
4. Kaplan Irving Nuclear Physics, Narosa Publishing House (2000).
5. Tayal D. C., Nuclear Physics, Himalaya Publication home (2007)
6. Perkins D.H., Introduction to High Energy Physics, Cambridge University Press (2000).
7. Hughes I.S., Elementary Particles, Cambridge University Press (1991).
8. Close F.E., Introduction to Quarks and Partons, Academic Press (1979).
9. Segre E., Nuclei and Particles, Benjamin-Cummings Pub. Co. (1997).
10. Khanna M.P., Introduction to Particle Physics, Prentice Hall of India Pvt. Ltd (2004).
11. G.N. Ghoshal, Nuclear Physics , S. Chand (2014)

MPH21-304 Classical Electrodynamics

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Boundary Value Problems: Uniqueness Theorem, Formal solution of Electrostatic & Magnetostatic Boundary value problem, Boundary conditions on electric and magnetic wave vector, Method of images with examples. 5 **lectures**

2. Time Varying Fields and Maxwell Equations: Faraday's Law of induction, Displacement current, Maxwell equations, scalar and vector potentials, Gauge transformation, Lorentz and Coulomb gauges, General Expression for the electromagnetic fields energy, Poyntingôs Theorem.

10 lectures

3. Electromagnetic Waves: Wave equation, Plane waves in free space and isotropic dielectrics, Polarization, Energy transmitted by a plane wave, Waves in conducting media, Skin depth. Reflection and Refraction of electromagnetic waves at plane surface between dielectrics, Fresnel's amplitude relations. Reflection and transmission coefficients, Polarization by reflection and total internal reflection. **10 lectures**

4. Wave Guides: Field at the surface of and within the conductor, Wave guides, TE, TM and TEM waves, Energy flow and attenuation in wave guides, Cavity resonators, Power loss in cavity and quality factor. **10 lectures**

5. Radiation Systems: Fields of radiation of a localized oscillating source, Electric & Magnetic dipole fields, Centre fed linear antenna, Introduction to radiation damping and radiation reaction.

10 lectures

Suggested Books:

1. Jordan E. C. and Balmain K. G., Electromagnetic Wave and radiating systems, Prentice Hall India Ltd. (1997).
2. Griffiths D.J., Introduction to Electrodynamics, Prentice Hall (1998).
3. Jackson J.D., Classical Electrodynamics, Wiley Eastern (1999)
4. Puri S.P., Classical Electrodynamics, Tata McGraw Hill (1999).

MPH21-305 Physics Lab-III

Internal Marks: 50 **L T P**
External Marks: 100 **0 0 6**
Total Marks: 150

The aim and objective of the courses on Physics Laboratory II is to expose the students of M.Sc. to the experimental techniques in condensed matter physics and nuclear physics, so that they can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments wherever necessary.

Note : Students are expected to perform at least 10 experiments in one semester.

1. To study the series and parallel characteristics of a photovoltaic cell.
2. To study the spectral characteristics of a photovoltaic cell.
3. Verification of Curie-Wiess law by studying temperature dependence of electrical susceptibility of a ferroelectric material.
4. Study of Thermoluminescence of f-centres in Alkali Halide Crystals.
5. To determine crystal structure of different material using x-ray diffraction.
6. To measure dielectric constant of Barium titanate as function of temperature and frequency and hence study its transition.
7. To measure heat capacity of solid at high and low temperatures.
8. To determine the dead time of given G. M Counter.
9. To study the statistical fluctuations of background counts in a G. M. Counter.
10. To determine the absorption coefficient of Pb and Fe for gamma rays using G. M. Counter.
11. To determine the energy of a pure beta-emitter using G.M. Counter and Al absorbers.
12. To study the energy resolution of Cs137.
13. To identify the unknown gamma source using energy calibration.
14. To study time regulation of gamma ï ray coincidence set-up
15. To study anisotropy of gamma-ray for 60Co using coincidence set-up
16. To study energy resolution and calibration of a gamma-ray spectrometer using multichannel analyzer.
17. To study time resolution and calibration of a coincidence set-up using a multi-channel analyzer.

MPH21-401 Physics of Nano Materials

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Introductory Aspects: Free electron theory and its features, Idea of band structure - metals, insulators and semiconductors. Density of states in bands and its variation with energy, Effect of crystal size on density of states and band gap. **10 lectures**

2. Nanostructures: Electron confinement in infinitely deep square well, Confinement in one and two-dimensional wells, Idea of quantum well structure, quantum dots, Confining excitons, Correlation of properties with size. **10 lectures**

3. Preparation of Nanomaterials: Bottom up: Ion beam deposition, Chemical bath deposition; Top down: Ball Milling, Lithography. **7 lectures**

4. Nanomaterials: Carbon nanostructures (carbon nanotubes) and its synthesis, mechanism of growth, Properties and applications of Carbon nanotubes, Nanosized metal particles and metal to insulator transition. **10 lectures**

5. General Characterization Techniques: Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, Raman and FTIR spectroscopy of nanomaterials. **8 lectures**

Suggested Books:

1. Chow G-M & Gonsalves K.E., Nanotechnology - Molecularly Designed Materials, American Chemical Society.
2. Jain K.P., Physics of Semiconductor Nanostructures, Narosa Publishing House (1997).
3. Cao, G., Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Emperial College Press (2004).

MPH21-402 Synthesis and Characterization of Materials

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Synthesis of Materials: Bulk Synthesis: Solid state reaction method, sol gel method, chemical precipitation method. Film deposition methods: Physical vapor deposition, Chemical vapor deposition, Spray pyrolysis, sputtering (RF, DC); Pulsed laser deposition (PLD), Spin coating technique. **10 lectures**

2. Microscopic Techniques: Transmission electron microscopy (TEM), Scanning electron microscopy (SEM); scanning tunneling microscopy (STM); Atomic force microscopy (AFM). **8 lectures**

3. Spectroscopic Techniques: Diffraction techniques: X-ray diffraction, data manipulation of diffracted X-rays for structure determination; X-ray fluorescence spectrometry for element detection with concentration; Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS). FTIR, UV-Visible spectroscopy. **12 lectures**

4. Electrical and Magnetic Characterization Techniques: Electrical resistivity, Dielectric properties in bulk and thin films, Hall effect, Magnetic characterization by measuring Magnetization viz. M-H loop, temperature dependent magnetization, time dependent magnetization, Measurements using AC susceptibility by Force and Induction method using Vibrating Sample magnetometer(VSM) and introduction to Superconducting Quantum Interference Device (SQUID). **15 lectures**

Suggested Books:

1. Thin Film Phenomena :K.L. Chopra-Mc Graw Hill Book, Comp.,1979.
2. Thin Film fundamentals: A. Goswami-New age International, 2007
3. Material Science and Engg :W.D. Callister-John Wiley, 2001
4. Elements of X-ray Diffraction (3rd edition) : B.D. Cullity, S.R. Stock-Prentice Hall, 2001.
5. X-ray Fluorescence spectroscopy: R. Jenkins-Wiley Interscience, New York, 1999.
6. Methods of Surface Analysis : J.M. Walls- Cambridge University Press, 1989.
7.The principles and Practice of Electron Microscopy: Ian M. Watt-Cambridge University Press, 1997
8. Modern techniques for surface science: D.P. Woodruff and T.A. Delchar- Cambridge University Press, 1994.
9. Dorothy Hoffman Handbook of Vacuum Science and Technology
11. "*Vacuum Technology*", 1983, A. Roth, Pergamon Press (Oxford).
12."Vacuum Technology and Applications, "1991, David J. Hucknall, Butterworth-Heinemann (Oxford).
13. "Low-temperature physics: an introduction for scientists and engineers, "1992, P V E McClintock, D J Meredith and J K Wigmore, Blackie (Glasgow).

MPH21-403 Physics Lab-IV

Internal Marks: 50 **L T P**
External Marks: 100 **0 0 6**
Total Marks: 150

The aim and objective of the courses on Physics Laboratory is to expose the students of M.Sc. to the experimental techniques in general Physics, so that they can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipment and prepare reports.

1. Experimental Methodology: Students will learn how to design a problem and write hypothesis, set up and perform experiments, analysis of obtained results, drawing inferences and conclusions, which will be followed by a detailed report of outcomes.

2. Students will be required to perform detailed study on a problem in one of the following fields:

- Experimental Physics
- Theoretical Physics

In all, it will be a collaborative work to perform experimental/theoretical work and to prepare final report, involving a maximum of 05 students in each group. The final evaluation will comprise of pre-submission seminar for Internal Evaluation (50 marks) and final presentation of results for External Evaluation (100 marks).

MPH21-404 Radiation Physics

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Ionizing Radiations and Radiation Quantities: Types and sources of ionizing radiation, fluence, energy fluence, kerma, exposure rate and its measurement - The free air chamber and air wall chamber, Absorbed dose and its measurement ; Bragg Gray Principle, Radiation dose units - rem, rad, Gray and sievert dose commitment, dose equivalent and quality factor.

10 Lectures

2. **Dosimeters:** Pocket dosimeter, films, solid state dosimeters such as TLD, SSNTD, chemical detectors and neutron detectors. Simple numerical problems on dose estimation.

10 Lectures

3. **Radiation Effects and Protection:** Biological effects of radiation at molecular level, acute and delayed effects, stochastic and nonstochastic effects, Relative Biological Effectiveness (RBE), Linear energy transformation (LET), Dose response characteristics. Permissible dose to occupational and non-occupational workers, maximum permissible concentration in air and water, safe handling of radioactive materials, The ALARA, ALI and MIRD concepts, single target, multitarget and multihit theories, Rad waste and its disposal, simple numerical problems.

15 Lectures

4. Radiation Shielding: Thermal and biological shields, shielding requirement for medical, industrial and accelerator facilities, shielding materials, radiation attenuation calculations-The point kernal technique, radiation attenuation from a uniform plane source. The exponential point-Kernal. Radiation attenuation from a line and plane source. Practical applications of some simple numerical problems.

10 Lectures

Suggested Books:

S. Glasstone and A. Sesonke: Nuclear Reactor Engineering-Van Nostrand Reinhold, 1981
2. Alison. P. Casart: Radiation Theory
3. A. Edward Profio: Radiation Biology-Radiation Bio/Prentice Hall, 1968
4. F.H. Attix: Introduction to Radiological Physics and Radiation Dosimetry-Wiley-VCH, 1986.

MPH21-405 Advanced Statistical Mechanics

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. **Interacting Systems**: Deviation of a real gas, Cluster expansion for a classical gas, Virial expansion of equation of state, Evaluation of virial coefficients, quantum mechanical ensemble theory, the density matrix, density matrix for a linear harmonic oscillator; Bose condensation. **12 Lectures**

2. **Phase Transitions and Critical Phenomena**: Phase transitions- General remarks on the problems of condensation, Dynamical model for phase transition- Ising and Heisenberg models, the lattice gas and binary alloy, Ising model in the Zeroth approximation, Matrix method for one dimensional Ising model. The critical indices, Law of Corresponding States, Thermodynamic inequalities. **12 Lectures**

3**. Brownian Motion:** Spatial correlation in a fluid, Einstein- Smoluchowski theory, Langevin theory, The Fokker-Planck equation. **9 Lectures**

4. **The Time Corelation Function Formalism:** Concept of time correlation function, derivation of basic formulas of linear response theory, The Wiener- Khintchine theorem, the fluctuation dissipation theorem. The Onsagar relations. **12 Lectures**

Suggested Books:

1. Statistical Mechanics: R. K. Pathria (Butterworth-Heinemann, Oxford), 3rd ed, 2011.
2. Statistical Mechanics : K. Huang (Wiley Eastern, New Delhi) 2011.
3 Elementary Statistical Physics : C. Kittel (Wiley, New York) (1958).

MPH21-406 Reactor Physics

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Interaction of Neutrons with Matter in Bulk: Thermal neutron diffusion, Transport and diffusion equations, transport mean free path, solution of diffusion equation for a point source in an infinite medium and for an infinite plane source in a finite medium, extrapolation length and diffusion length-the albedo concept. 10 **Lectures**

2. Moderation of Neutron: Mechanics of elastic scattering, energy distribution of thermal neutrons, average logarithmic energy decrement, slowing down power and moderating ration of a medium. Slowing down density, slowing down time, Fast neutron diffusion and Fermi age theory, solution of age equation for a point source of fast neutrons in an infinite medium, slowing down length and Fermi age.

12 Lectures

3. Theory of Homogeneous Bare Thermal and Heterogeneous Natural Uranium Reactors
Neutron cycle and multiplication factor, four factor formula, neutron leakage, typical calulations of critical size and composition in simple cases, The critical equation, material and geometrical bucklings, effect of reflector, Advantages and disadvantages of heterogeneous assemblies, various types of reactors with special reference to Indian reactors and a brief discussion of their design feature. 13 **Lectures**

4. Power Reactors Problems of Reactor Control
Breeding ratio, breading gain, doubling time, Fast breeder reactors, dual purpose reactors, concept of fusion reactors, Role of delayed neutrons and reactor period, Inhour formula, excess reactivity, temperature effects, fission product poisoning, use of coolants and control rods.

10 Lectures

Suggested Books:

1. The elements of Nuclear reactor Theory: Glasstone & Edlund-Vam Nostrand, 1952.
2. Introductions of Nuclear Engineering: Murray-Prentice Hall, 1961.

MPH21-407 Fibre Optics and Non-Linear Optics

Internal Marks: 50 **L T P**
External Marks: 100 **4 1 0**
Total Marks: 150

1. Optical fibre, its properties and fabrication : Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and band width, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types. Fibre fabrication, mass production of fibre, comparison of the processes, fibre drawing process, coatings, cable design requirements, typical cable design, testing. **12 lectures**

2. Optics of anisotropic media: Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and Poynting vector S, the indicatrix, uniaxial crystals, index surfaces, other surfaces related to the uniaxial indicatrix, Huygenian constructions, retardation, biaxial crystals, intensity through polarizer/waveplate/polarizer combinations. **12 lectures**

3. Electro-optic and acousto-otpic effects and modulation of light beams: Introduction to the electrooptic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro-optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a longitudinal acoustic wave in isotropic medium, calculation of LM for a shear wave in lithium niobate, Raman-Nath diffraction, Raman-Nath acousto-optic modulator. **15 lectures**

4. Nonlinear optics and processes : Introduction, anharmonic potentials and nonlinear polarization, non-linear susceptibilities and mixing coefficients, parametric and other non-linear processes, macroscopic and microscopic susceptibilities. 6 **lectures**

Suggested Books:

1. The Elements of Fibre Optics: S.L.Wymer and Meardon (Regents/Prentice Hall) (1993).
2. Lasers and Electro-Optics: C.C. Davis (Cambridge University Press) (2000).
3. Optical Electronics : Gathak & Thyagarajan (Cambridge Univ. Press) (1989).
4. The Elements of Non-linear Optics: P.N. Butcher & D. Cotter (Cambridge University Press) (1990).