PUNJAB TECHNICAL UNIVERSITY

Scheme& Syllabus of M.Sc. Physics

Batch 2012

Master of Science (M.Sc.) in Physics: It is a Post Graduate (PG) programme in Physics of 02 years (4 semesters) duration.

Eligibility for Admission: B.Sc. with Physics & Mathematics as compulsory subjects with at least 50 % marks in aggregate, in the qualifying examination.

Courses & Examination Scheme:

First Semester

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MPH-101	Mathematical Physics	4	1	0	50	100	150	5
MPH-102	Classical Mechanics	4	1	0	50	100	150	5
MPH-103	Thermodynamics & Statistical Physics	4	1	0	50	100	150	5
MPH-104	Semiconductors and Electronic Devices	4	1	0	50	100	150	5
MPH-105	Semiconductors & Electronics Lab	0	0	6	50	100	150	3
MPH-106	Fundamentals of Computer Science & Programming	1	0	2	50	100	150	2
	Total	**17**	**04**	**08**	**300**	**600**	**900**	**25**

Second Semester

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MPH-201	Quantum Mechanics	4	1	0	50	100	150	5
MPH-202	Optoelectronics, Lasers and its Applications	4	1	0	50	100	150	5
MPH-203	Solid State Physics	4	1	0	50	100	150	5
MPH-204	Nuclear & Particle Physics	4	1	0	50	100	150	5
MPH-205	Nuclear Physics Lab	0	0	6	50	100	150	3
MPH-206	Computational Methods & Programming	2	0	4	50	100	150	4
	Total	**18**	**04**	**10**	**300**	**600**	**900**	**27**

Note: For promotion to the 3rd Semester, a student needs to have minimum aggregate 45 % marks in the 1st Year (irrespective of any number of reappears)

Third Semester

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MPH-301	Atomic & Molecular Physics	4	1	0	50	100	150	5
MPH-302	Electrodynamics	4	1	0	50	100	150	5
MPH-303	Materials Testing and Characterization Techniques	4	1	0	50	100	150	5
MPH-304	Condensed Matter Physics	4	1	0	50	100	150	5
MPH-305	Materials Physics Lab	0	0	6	50	100	150	3
	Total	**16**	**04**	**06**	**250**	**500**	**750**	**23**

Fourth Semester

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MPH-401	Radiation Physics & Nuclear Accelerators	4	1	0	50	100	150	5
MPH-402	Physics of Nanomaterials	4	1	0	50	100	150	5
MPH-403	Dissertation*	06			125	125	250	5
	Total	**08**	**02**	**06**	**225**	**325**	**550**	**15**

NOTES:

1. Three alphabet course code MPH stands for M.Sc. Physics.
2. Each lecture is of one hour duration.
3. The overall pass percentage in the two years course is 45% in aggregate.

---

* **It will be an integrated dissertation, involving a maximum of 05 students in each group. The components of the Dissertation are as follows;**

- **Thesis (Internal Evaluation) (125 Marks)**
- **Presentation (External Evaluation) (125 Marks)**
- **Pre-submission Seminar (Internal Evaluation) (Satisfactory / Unsatisfactory)**

Paper MPH-101
MATHEMATICAL PHYSICS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I Elements of complex analysis:
Introduction, Laurent series-poles, residues and evaluation of integrals; Cauchy-Riemann conditions, Cauchy's Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals.
Elementary ideas about tensors, Dispersion relation.

II Fourier Analysis, Laplace Analysis & Inverse Laplace Analysis:
Fourier series of periodic functions, even and odd functions, half range expansions and Fourier series of different wave forms, complex form of Fourier series and practical harmonic analysis. Fourier transforms of various standard functions.
Laplace transforms of various standard functions, properties of Laplace transforms and inverse Laplace transforms and Inverse Laplace Analysis.

III Differential Equations: Linear differential equations with constant coefficients, Cauchy's homogeneous linear equation, Partial differential equations of theoretical physics, separation of variables, singular points, series solutions, second solution.

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

V Group Theory: Definition of a group, Multiplication table, Conjugate elements and classes of groups, directs product, Isomorphism, homeomorphism, permutation group, Definitions of the three dimensional rotation group and SU(2), O(3);

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.

II. The students are required to attempt FIVE questions in all including the Compulsory question.

III. All questions carry equal marks.

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 – 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

Paper MPH-102
CLASSICAL MECHANICS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

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.

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

II 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 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.

IV Small Oscillations: Eigen value equation, Free vibrations, Normal Coordinates, Vibrations of a tritomic molecule.

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

VI 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.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.
II. The students are required to attempt FIVE questions in all including the Compulsory question.
III. All questions carry equal marks.

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).

Paper MPH-103

THERMODYNAMICS & STATISTICAL PHYSICS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I Basics of Thermodynamics: Laws of thermodynamics and their consequences; Thermodynamic potentials, Maxwell relations; Chemical potentials, Phase equilibria;

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

III Ensemble Theory: Phase space and Liouville's theorem, the microcanonical 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.

IV Quantum Statistics of Ideal Systems: Quantum states and phase space, an ideal gas in quantum mechanical ensembles, statistics of occupation numbers; 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 behaviour of an ideal Fermi gas, discussion of heat capacity of a free-electron gas at low temperatures, Pauli paramagnetism.

V Fluctuations: Thermodynamic fluctuations, random walk and Brownian motion, introduction to nonequilibrium processes, diffusion equation.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.

II. The students are required to attempt FIVE questions in all including the Compulsory question.

III. All questions carry equal marks.

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

Paper MPH-104
SEMICONDUCTORS AND ELECTRONIC DEVICES

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I Semiconductor Theory and Devices

Introduction to semiconductors, Drift and diffusion of carriers, Fermi level, Photoconductors, Capacitance of p-n junctions, Varactors, switching diodes, Tunnel diode, Direct and indirect semiconductors, 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 and Logic.

II Circuit Analysis

Lumped circuits, Non-linear resistors-series and parallel connections, D.C. operating points, small signal analysis, Thevenin and Norton theorems, Mesh and Node analysis. First-order nonlinear circuits, Dynamic route, jump phenomenon and relaxation oscillator, triggering of bistable circuits.

III Analog Electronics

Differential amplifiers, common mode rejection ratio, Transfer characteristics, OPAMP configurations, open loop and close loop gain, inverting, non-inverting and differential amplifier, Basic characteristics with detailed internal circuit of IC Opamp, slew rate, Comparator characteristics, Window comparator, 555 timer based circuits, Summing amplifier, Logarithmic and anti-logarithmic amplifiers, Current-to-voltage and Voltage-to-current converter, Voltage regulation circuits, Electronic circuits–Phase shift oscillator, Wien bridge oscillator, rectangular wave generators.

IV Digital Electronics:

Introduction to Digital electronics, Basic digital logic circuits, sequential circuits, flip flops, counters, registers, A/D and D/A conversion, Overview of VLSI, VLSI circuits and IC design fundamentals.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.
II. The students are required to attempt FIVE questions in all including the Compulsory question.
III. All questions carry equal marks.

Books

1. Semiconductor Devices - Physics and Technology by S.M. Sze(Wiley)
2. Applications of Laplace Transforms by Leonard R. Geis (Prentice Hall, New Jersey)
3. Linear and Non-linear Circuits by Chua, Desoer and Kuh(Tata McGraw)
4. Integrated Electronics by Millman and Halkias(Tata McGraw Hill)
5. Electronic devices and Circuit theory by Boylestad and Nashelsky(Preutice Hall).
6. OPAMPS and Linear Integrateed circuits by Ramakant A Gayakwad (Prentice Hall).
7. Electronic Principles by A.P. Malvino(Tata McGraw, New Delhi).
8. The Elements of Fibre Optics : S.L. Wymer (Regents/Prentice Hall)
9. Electronic Communication Systems : Kennedy and Davis (Tata McGraw Hill).
10. Digital Electronics by Malvino and Leach.
11. Semiconductor Physics by Maan Singh.
12. Semiconductor Physics by Choudhary

Paper MPH-105

SEMICONDUCTORS AND ELECTRONICS LAB

M. Marks External Exam: 100 **66 Hrs. (6 Hrs./week)**

Note: Students will be required to perform at least ten experiments from the given list of experiments

1. To determine the band gap of given semiconductor crystal using four probe method.
2. To study various displays and drivers on a bread-board – Assembling circuits on breadboard.

3. Design of Regulated power supply and study of its characteristics.
4. To trace I-V characteristic curves of diodes and transistors on a CRO, and learn their uses in electronic circuits.
5. To study the characteristics of given a stable multivibrator.
6. To study the use of digital to analog and analog to digital converter.
7. Study the clipper and clamper circuits.
8. MOSFET characteristics, biasing and its applications as an amplifier.
9. The Hall coefficient for given semiconductor and study its temperature dependence.
10. To study the demodulation of AM wave. (ii) To study various aspects of frequency modulation and demodulation.
11. To study the frequency response of an operational amplifier & to use operational amplifier for different mathematical operations.
12. Use of timer IC 555 in astable and monostable modes and applications involving different relays and LDR.
13. To study logic gates and flip flop (JK, RS and D) circuits using on a bread-board.
14. 8085 microprocessor kit – familiarization and introductory programming.

Paper MPH-106

FUNDAMENTALS OF COMPUTER SCIENCE AND PROGRAMMING

M. Marks External Exam: 100 **33 Hrs. (1L+2P Hrs./week)**

I Introduction to Computers: Chronological developments in computers, Computer systems, Hardware and Software; CPU, Primary memory, Secondary storage devices, Input devices, Output devices, Significance of software in computer system, Categories of software – system software, Application software, Compiler, Interpreter, Utility program, Binary arithmetic for integer and fractional numbers, Operating system and its significance.

II C/C++ Programming: Introduction to algorithm, Flow charts, Problem solving methods, Need of programming languages. C character set, Identifiers and keywords, Data types, Declarations, Statement and symbolic constants, Input-output statements, Preprocessor commands, Operators, expressions and library functions, Control statements: Conditional, Unconditional, Bi-directional, Multi-directional and loop control structures, Functions, Arrays, Strings, Introduction to Pointers, Structure and union, Files.

Recommended Books:

1. Norton Peter, Introduction to Computers, Tata McGraw Hill (2005).
2. Kerninghan B.W. and Ritchie D.M., The C programming language, PHI (1989)
3. Kanetkar Yashawant, Let us C, BPB (2007).
4. Rajaraman V., Fundamentals of Computers, PHI (2004).

Paper MPH-201
QUANTUM MECHANICS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

1. **Introduction to Quantum Mechanics**
   Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigen value problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors.
2. **Symmetry in Quantum Mechanics**
   Symmetry operations and unitary transformations, conservation principles, space and time translations, rotation, space inversion and time reversal, symmetry and degeneracy.
3. **Angular Momentum**
   Wave-function in momentum representations. Rotation operators, angular momentum algebra, eigenvalues of J^2 and J_z, spinors and Pauli matrices, Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment..
4. **Identical Particles**
   Indistinguishability, symmetric and antisymmetric wave functions, incorporation of spin, Pauli exclusion principle, spin-statistics connection. Spin-orbit coupling, fine structure.
5. **Time-independent Approximation Methods**
   Non-degenerate perturbation theory & its applications, degenerate case, variational methods, WKB approximation.
6. **Time-dependent Problems**
   Time-dependent perturbation theory, transition probability calculations, golden rule, adiabatic approximation, sudden approximation, beta decay as an example.
7. **Elementary theory of scattering:** phase shifts, partial waves, Born approximation. Relativistic quantum mechanics: Klein-Gordon and Dirac equations. Semi-classical theory of radiation.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.
II. The students are required to attempt FIVE questions in all including the Compulsory question.
III. All questions carry equal marks.

References:

1. C. Cohen-Tannoudji, B. Diu and F. Laloe, *Quantum Mechanics (Vol.I and II).*
2. L.I. Schiff, *Quantum Mechanics.*

3. E. Merzbacher, *Quantum Mechanics*.
4. R.P. Feynman, *Feynman Lectures on Physics (Volume 3).*
5. A. Messiah, *Quantum Mechanics (Vol. I & II).*
6. R. Shankar, *Principles of Quantum Mechanics.*
7. **S. Flügge,** *Practical Quantum Mechanics.*
8. **J.J. Sakurai,** *Modern Quantum Mechanics.*
9. **K. Gottfried,** *Quantum Mechanics.*

Paper MPH-202

OPTOELECTRONICS, LASERS & ITS APPLICATIONS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I. Optoelectronics: Photo detectors, photodiodes, Solar cell, LED, LCD, seven segment display. **Fibre Optics;** Introduction to optical fibre**,** construction & types, Basic parameters, normalized frequency.

II Basics of Lasers: Population Inversion, Einstein Coefficients and Light Amplification, Laser Rate Equations; Two-level, Three-level, and Four-level Laser Systems, Optical Resonators, Axial and Transverse Modes, Q-switching and Mode Locking in Lasers, Coherence Properties of Laser Light, Temporal Coherence, Monochromaticity, Spatial Coherence, Directionality, Linewidth, Brightness, Focusing Properties of Laser Radiation & Tunability.

III Types of Lasers: Doped-insulator Lasers: Ruby Laser, Nd: YAG and Nd: Glass Laser; Gas Lasers: Atomic Lasers – He Ne Laser, Ion Lasers: Argon Laser, Molecular Lasers: Carbon Dioxide Laser, Nitrogen Laser, and Excimer Laser; Liquid Dye Laser; Semiconductor Laser.

IV Applications of Lasers: Measurement of distance – Interferometric methods, Beam modulation telemetry, Pulse echo techniques; Laser Tracking, LIDAR, Holography, Applications of Holography: Holographic Interferometry - Double Exposure , Real Time, and Time Average; Laser Cooling, Material Processing - Lasers in Welding, Drilling, and Cutting, Medicine, Laser-induced Fusion, Resistor Trimming, Laser Soldering, Laser Heat Treatment; Information Storage, Bar Code Scanner,.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.

II. The students are required to attempt FIVE questions in all including the Compulsory question.

III. All questions carry equal marks.

Recommended Books:

- Thyagarajan K. and Ghatak A K, Lasers Theory and Applications, Macmillan India Limited, (1995).
- Ghatak Ajoy and Thyagarajan K., Fiber Optics and Lasers, Macmillan India Limited (2006).
- Wilson J. and Hawkes J.F.B., Optoelectronics, An Introduction, Prentice-Hall of India Private Limited (1993).
- **Laser and Non Linear Optics** by **B.B.** Laud.
- Principle of optical communications by Senior.

Paper MPH-203
SOLID STATE PHYSICS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I Crystal Structure

Crystals, Bravais lattice, symmetry operations and classification of Bravais lattices, common crystal structures, Liquid and Quasi crystals, X-ray diffraction, Bragg's law.

II Defects and Diffusion in solids:

Defects; Point defect (Sthottky & Frenkel), Line defect/dislocations (Berger vector), Surface defects, Volume defects, Colour center, Diffusion in solids, Classification of diffusion process, Mechanism of atomic diffusion, Ficks law, Factor affecting diffusion and applications, Kirkendal law

II Free Electron Theory:

Drude and Lorentz theory; Electrical and thermal conductivity, Hall effect and magneto-resistance, thermo-electric power. Bonding of solids, elastic Properties, phonons, lattice specific heat, Brillouin zone, Reciprocal Lattice, Crystal field, Bloch Theorem, Wave packets of Bloch electrons, semi-classical equations of motion, motion in static electric and magnetic fields, theory of holes.

III Lattice Dynamics

Failure of the static lattice model, harmonic approximation, vibrations of a one-dimensional lattice, one-dimensional lattice with basis, models of three-dimensional lattices, quantization of vibrations, Einstein and Debye theories of specific heat, phonon density of states, neutron scattering.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.
II. The students are required to attempt FIVE questions in all including the Compulsory question.
III. All questions carry equal marks.

Recommended 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

Paper MPH-204
NUCLEAR & PARTICLE PHYSICS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I Nuclear Interactions nad Nuclear Reactions

Nucleon- nucleon interaction- Exchange forces and tensor forces- meson theory of nuclear forces- Nucleon- nucleon scattering- Effective range theory—Spin dependence of nuclear forces—Charge independence and charge symmetry of nuclear forces—leospin formalism—Yukawa interaction. Direct and compound nuclear reaction mechanisms- Cross section in terms of partial wave amplitude—Compound nucleus – Scattering matrix- Reciprocity theoerem—Breit-Wigner one-level formula-Resonance Scattering.

II Nuclear Methods

Liquid Drop Model-Bohr-Wheelar theory of fission- Experimental evidence for shell effects- Shell Model- spin- Orbit coupling-Magic numbers-Angular momenta and parities of nuclear ground states- Qualitative discussion and estimates of transition rates- Magnetic moments and Schmidt lines- Collective model of Bohr and Mottleson.

III Nuclear Decay

Beta decay- Fermi theory of beta decay—Shape of beta spectrum-Total decay rate-Angular momentum and parity selection rules- Comparative half-lives- Allowed and forbidden transitions—Selection rules-Parity violation-Two component theory of neutrino decay—Detection and properties of neutrino—Gamma decay- Multiple transitions in nuclei- Angular momentum and parity selection rules- Internal conversion- Nuclear isomerism.

IV Elementary Particle Physics

Types of interaction between elementary particles- Hadrons and Leptons- Symmetry and conservative laws- Elementary ideas of CP and CPT invariance—Classification of Hadrons—Lle algebra, SU (2)—SU(3) multiples-Quark model- Gell-Mann- Okubo mass formula for octet and decuplet hadrons—Charm, bottom and top quarks.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.

II. The students are required to attempt FIVE questions in all including the Compulsory question.

III. All questions carry equal marks.

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).

Paper MPH-205
NUCLEAR PHYSICS LAB.

M. Marks External Exam: 100 **66 Hrs. (6 Hrs./week)**

Note: Students will be required to perform at least ten experiments from the given list of experiments

1. Analysis of pulse height of gamma ray spectra.
2. To study absorption of beta rays in Al and deduce end-point energy of a beta emitter.
3. To study the dead time and other characteristics of G.M. counter.
4. To study Gaussian distribution and Source strength of a beta-source using G.M. counter.
5. Recording and calibrating a gamma ray spectrum by scintillation counter.
6. Detecting gamma radiation with a scintillation counter.
7. Identifying and determining the activity of weakly radioactive samples.
8. To calibrate the given gamma-ray spectrometer and determine its energy resolution.
9. Energy resolution and calibration of a gamma-ray spectrometer using multi-channel analyzer.

10. Time resolution and calibration of a coincidence set-up using a multi- channel analyzer.
11. Formation and Counting of alpha particle tracks on Solid State Nuclear Track Detectors using Optical Microscope/ spark counter.
12. Determination of Ionization Potential of Lithium.
13. Determination of Lande's factor of DPPH using Electron-Spin resonance (E.S.R.) Spectrometer.

Paper MPH-206
COMPUTATIONAL METHODS & PROGRAMMING

M. Marks External Exam: 100 **55 Hrs. (2L+4P Hrs./week)**

I Numerical Algebraic and Transcendental Equations
Methods for determination of zeroes of linear and nonlinear algebraic and transcendental equations, Convergence of solutions, Solution of simultaneous linear equations, Evaluation of numerical determinants, Gaussian elimination and pivoting, Matrix inversion, Iterative methods.

II Interpolation and Approximation
Introduction to interpolation, Lagrange approximation, Newton polynomials, Curve fitting by least squares, Polynomial least squares and cubic splines fitting.

III Numerical Differentiation and Integration
Numerical differentiation, Quadrature, Simpson's rule, Gauss's quadrature formula, Newton – Cotes formula.

IV Random Variables and Monte Carlo Methods
Random numbers, Pseudo-random numbers, random number generators, Monte Carlo integration: Area of circle, Moment of inertia, Monte Carlo Simulations: Buffen's needle experiment, Random walk, Importance sampling.

V Differential Equations
Euler's method, Runge Kutta methods, Predictor-corrector methods, Finite difference method, Finite difference equations for partial differential equations and their solution.

VII Laboratory Assignments (Do any Eight from the list below)

1. To find mean, standard deviation and frequency distribution of an actual data set from any physics experiment.
2. To solve Kepler equation by Newton-Raphson method,
3. Van der Wall gas equation for volume of a real gas by the method of successive approximation.
4. Interpolate a real data set from an experiment using the Lagrange's method.
5. Newton's method of forward differences and cubic splines.

6. Fit the Einstein's photoelectric equation to a realistic data set and hence calculate Plank's constant.
7. Estimate the value of π by rectangular method,
8. Find the area of a unit circle by Monte Carlo integration.
9. To simulate Buffen's needle experiment.
10. To simulate the random walk.
11. To study the motion of an artificial satellite by solving the Newton's equation for its orbit using Euler method.
12. Study the growth and decay of current in RL circuit containing (a) DC source and (b) AC using Runge Kutta method. Draw graphs between current and time in each case.
13. Study the motion of two coupled harmonic oscillators. Compare the numerical results with the analytical results.

Recommended Books:

- Mathews J.H., Numerical Methods for Mathematics, Science and Engineering, Prentice-Hall (2000).
- Jain N.K., Iyengar S,R.K. & Jain R.K., Numerical Methods for Scientific & Engg. Computations, New Age International.
- Gerald C.F. & Wheatley P.O., Applied Numerical Analysis, PHI
- Atkinson K.E., An Introduction to Numerical Analysis,

Paper MPH-301

ATOMIC & MOLECULAR PHYSICS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I 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.

II 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.

III 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.

IV Atom in Electric Field

Stark effect, First order Stark effect in hydrogen.

V 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.

VI Spin Resonance Spectroscopy: Electron spin resonance and nuclear magnetic resonance spectroscopy.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.
II. The students are required to attempt FIVE questions in all including the Compulsory question.
III. All questions carry equal marks.

Recommended Books:

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

Paper MPH-302
ELECTRODYNAMICS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I Boundary Value Problems: Uniqueness Theorem, Dirichlet or Neumann Boundary conditions, Green's Theorem, Formal solution of Electrostatic & Magnetostatic Boundary value problem, Method of images with examples.

II 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, Hertz potential, General Expression for the electromagnetic fields energy, Conservation of energy, Poynting’s Theorem, Conservation of momentum.

III 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 interface, Fresnel's amplitude relations. Reflection and transmission coefficients, Polarization by reflection. Brewster's angle, Total internal reflection, EM wave guides, TE, TM and TEM waves, Rectangular wave guides. Energy flow and attenuation in wave guides, Cavity resonators.

IV Radiation from Localized Time Varying Sources: Solution of the inhomogeneous wave equation in the absence of boundaries. Fields and Radiation of a localized oscillating source, Electric dipole and electric quadrupole fields, Centre fed linear antenna.

V Charged Particle Dynamics: Non-relativistic motion in uniform constant fields and in a slowly varying magnetic field. Adiabatic invariance of flux through an orbit, magnetic mirroring, Relativistic motion of a charged particle.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.
II. The students are required to attempt FIVE questions in all including the Compulsory question.
III. All questions carry equal marks.

Recommended Books:

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

Paper MPH-303
MATERIALS TESTING AND CHARACTERIZATION TECHNIQUES

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I Introduction: Statistical errors in measurements, important parameters describing the materials, crystal defects, Need of materials characterization, available Characterization techniques.

II Light / Optical Microscopy: Optical microscope- basic principles & components. Stereomicroscopy, Photomicroscopy, Colour metallography, Photo- luminescence, AFM/STM, SEM & TEM.

III Quantitative Image Analysis: Basic measurements (Grain size, Particle morphology, Particle size & size distribution), Software for data analysis, Applications

IV Thermal Analysis: Thermogravimetric analysis, Differential thermal analysis, Differential scanning calorimetry, Thermomechanical analysis and dilatometry

V Powder Characterisation: Important properties of powders and measurement techniques: X-ray diffraction, structure determination.

VI Mechanical Testing: Introduction of important Mechanical properties of materials, Tensile Hardness impact fatigue, creep, Torsion testing,

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.

II. The students are required to attempt FIVE questions in all including the Compulsory question.

III. All questions carry equal marks.

Recommended Books:

- Wendlandt, W.W., Thermal Analysis, John Wiley & Sons (1986)
- Raj B., Jayakumar, T., Thavasimuthu, M., Practical Non-Destructive Testing, Narosa Publishers (2002).
- Wachtman, J.B., Kalman, Z.H., Characterization of Materials, Butterworth-Heinemann, (1993).
- Elements of X-Ray Diffraction by B. D. Cullity

Paper MPH-304

CONDENSED MATTER PHYSICS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I Dielectric Properties of Solids

Dielectric constant of solids using phenomenological theory (Maxwell's equations), polarization and ferroelectric, polarization catastrophe peizo- and pyroelectric solids, polymer and liquids, crystalline ferroelectrics, inter-band transitions, Kramers-Kronig relations, polarons, excitons, optical properties of metals and insulators. Polariton and LST theory.

II Transport Properties of Solids

Boltzmann transport equation, Mattheissen-Nordhein theory of electrical resistivity, resistivity of metals and semiconductors, thermoelectric phenomena, Onsager coefficients.

III Many-electron Systems

Sommerfeld expansion, Hartree-Fock approximation, exchange interactions, concept of quasi-particles, introduction to Fermi liquid theory, screening, plasmons.

IV Introduction to Strongly Correlated Systems

Narrow band solids, Wannier orbitals and tight-binding method, Mott insulator, electronic and magnetic properties of oxides, introduction to Hubbard model.

V Magnetism

Magnetic interactions, Heitler-London method, exchange and super-exchange, magnetic moments and crystal-field effects, ferromagnetism, spin-wave excitations and thermodynamics, antiferromagnetism, spintronics, Introduction to Multiferroics.

VI Superconductivity

Basic phenomena, excitations and energy gap, magnetic properties of type-I and type-II superconductors, London equations, Cooper pairs, coherence, Josephson effect, BCS theory, Ginzburg-Landau theory, Ginzburg-Landau- Abrikosov theory of Type II superconductors, introduction to high-temperature superconductors.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.

II. The students are required to attempt FIVE questions in all including the Compulsory question.

III. All questions carry equal marks.

Recommended Books:

1. **W. Ashcroft and N.D. Mermin,** *Solid State Physics.*
2. **D. Pines,** *Elementary Excitations in Solids.*
3. **S. Raimes,** *The Wave Mechanics of Electrons in Metals.*
4. **P. Fazekas,** *Lecture Notes on Electron Correlation and Magnetism.*
5. **M. Tinkham,** *Introduction to Superconductivity.*
6. **M. Marder,** *Condensed Matter Physics.*

Paper MPH-305
MATERIALS PHYSICS LAB

M. Marks External Exam: 100 **66 Hrs. (6 Hrs./week)**

Note: Students will be required to perform at least ten experiments from the given list of experiments

1. To study the dielectric behavior of PZT ceramic by determining Curie temperature, dielectric strength & dielectric constant.
2. To measure the dielectric losses (Tan Delta) of different polymer/ composites with temperature change at different frequencies.
3. Preparation and study of ferro-electricity in a ferroelectric material/ composite film prepared in laboratory.
4. To study the characteristics of a LED and determine activation energy.
5. Magneto-resistance and its field dependence.
6. To verify the existence of Bohr's energy levels with Frank-Hertz experiments.
7. To trace hysteresis loop and calculate retentivity, coercivity and saturation magnetization.

8. Determination of crystal structure & lattice parameters using X-rays diffraction technique.
9. Sizing nano-structures (UV-VIS spectroscopy).
10. Synthesis of nanomaterials using sol gel / solvent cast/ balls milling techniques and its surface characterization using optical microscope/AFM/ FESEM.
11. DSC/DTA/TGA studies for thermal analysis of materials.
12. Electrical properties of thin film deposited through vacuum/sputtering technique.

Paper MPH-401

NUCLEAR ACCELERATORS & RADIATION PHYSICS (NARP)

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I Interactions of Nuclear Radiations and Neutron Detection
Introduction to radiations, Biological effects of radiation, radiation monitoring. Neutron classification, sources of neutrons, Neutron detectors, Slow neutron detection through nuclear reactions and induced radioactivity, Fast neutron detection, Neutron monochromators, Diffusion of thermal neutrons.

II Nuclear Radiation Detectors
Detection of nuclear radiation and their measurement: Methods for detection of free charge carriers, ionization chamber, Proportional counter, Geiger-Muller counter, Semi-conductor detectors for X-rays, gamma rays, and charged particles detection, Cherenkov detector, Wilson cloud chamber, Bubble chamber, Spark chamber, Nuclear emulsion techniques, Solid state nuclear track detectors, Gas filled detectors.

III Nuclear Accelerators
Accelerators of charged particles: Classification and performance characterstics of accelerators, ion sources, Electrostatic accelerators, Cockroft---Walton generator, Cyclotron, Synchro-cyclotron, Betatron, Electron and Proton synchrotron, Microtron, Linear accelerators.

IV Nuclear reactors: Boiling water reactors, Pressurized water reactors, Pressurized heavy water reactors, Light water cooled graphite moderated reactors, Gas cooled reactors, Advanced gas cooled reactors, High temperature gas cooled reactors and liquid metal cooled reactors and Fast breeder reactors.

V Safety Aspects, Fuel and waste management: Radiation dose unit, Safety limits, Dose calculations, Design consideration of simple shields. Fuel management schemes, Fuel composition, Fuel cycle cost and waste management.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.

II. The students are required to attempt FIVE questions in all including the Compulsory question.
III. All questions carry equal marks.

Books

1. Edward J.N. Wilson “Ann introduction to Paricle Accelerators”, Oxford University Press,2003.
2. James Rosenzweig “Fundamantal of Beam Physisc”, Oxford University Press,2001.
3. P N Cooper “Introduction to Nuclear Radiation Detectors”, Cambridge University press, 1986.
4. Kapoor S S and Ramamurthy V S “Nuclear Radiation Detectors”, Wiley Eastern, new Delhi, 1986.
5. Knoll G. F., Radiation Detection and Measurement, John Wiley & Sons (1989).
6. Krane K. S., Introductory Nuclear Physics, John Wiley & Sons (1975).
7. Singuru R. M., Introduction to experimental nuclear physics, Wiley Eastern Publications(1987).

Paper MPH-402
PHYSICS OF NANOMATERIALS

M. Marks External Exam: 100 **55 Hrs. (4L+1T Hrs./week)**

I Introduction to the Nanoscience

Nano scale, Surface to volume ratio, Electron confinement in infinitely deep square well, Confinement in one and two-dimensional wells, Idea of quantum well structure, quantum dots – single and interacting quantum dots, self organized quantum dots. Nano rods.

II Synthesis of Nanomaterials

Bottom up: Cluster beam evaporation, Ion beam deposition, Pulse Laser Deposition, Chemical bath deposition; Top down: Ball Milling, Sol Gel Technique, Lithography.

III General Characterization Techniques

Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, photo luminescence (PL), Raman and FTIR spectroscopy of nanomaterials, Photoemission microscopy, FE-SEM, TEM.

IV Other Nanomaterials

Properties and applications of Carbon nanotubes and nano fibres, Nanosized metal particles, Nanostructured polymers, Nano structured films and Nano structured semiconductors.

Instructions for paper setters and candidates:

I. Examiner will set total of NINE questions comprising ONE compulsory question of short answer type covering whole syllabi.

II. The students are required to attempt FIVE questions in all including the Compulsory question.

III. All questions carry equal marks.

Recommended Books:

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