Faculty of Physical Sciences

Course Name: M.Sc. - Physics

PDM University, Bahadurgarh, Haryana – 124507

Established under Haryana Private Universities

(Amendment), Act, 2015 (Haryana Act No.1 of 2016)

Faculty of Physical Sciences
Department of Physics
M Sc Physics (1st Semester)
Physics Core

Module: Classical Mechanics	**Sessional Marks: 40**
Module Code: PHYS5101	**Theory Paper Marks: 60**
Lecture: 4 Tutorial: 1	**Total Marks: 100**
Credit: 4.5	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Lagrangian formulation of dynamics, generalized coordinates and constraints
- Moving cocordinate systems and motion in central force field
- Hamilton's principle of least action and Hamillton's equations
- Small oscillations and rigid body dynamics

Course Contents:

Unit 1: Survey of Elementary Principles and Lagrangian Formulation.

Newtonian mechanics of one and many particle systems; conservation laws, constraints, their classification; D' Alembert's principle, Lagrange's equations; dissipative forces generalized coordinates and momenta; Cyclic coordinates. Integrals of motion; symmetries of space and time and their connection with conservation laws.

Unit 2: Motion in a central force field.

Central force; definition and characteristics; two body problem; Equation of motion under the influence of central force field. Equation of an orbit. Classification of orbits. closure and stability of circular orbits;. General analysis of orbits; Kepler's problem. Derivation of Kepler's laws ; Classical theory of scattering; Rutherford scattering.

Unit 3: Variational Principle, Equation of motion , Canonical Transformations and Hamilton-Jacobi Equation.

Principle of least action; derivation of equations of motion; Hamilton's equations; Hamilton's principle and characteristic functions;. Canonical transformation; generating functions, properties of Poisson bracket, angular momentum Poisson brackets Hamilton-Jacobi equation.

Unit 4: Rigid Body dynamics and Small Oscillations

Rotating frames; and the concept of coriolis force; Definition and DOF of a rigid body. Rigid body dynamics; Small oscillations; Normal modes and coordinates.

Text Books:

1. Classical Mechanics: H Goldstein
   Addison Wesley, New York
2. Classical Mechanics:N C Rana and P S Joag
   Tata McGraw Hill, New Delhi
3. Classical Mechanics: V B Bhatia
   Narosa Publishing House, New Delhi
4. Mechanics: L D Landau and E M Lifshitz
   Oxford, Pergamon, UK

Faculty of Physical Sciences
Department of Physics
M Sc Physics (1st Semester)
Physics Core

Module: Quantum Mechanics-I	**Sessional Marks: 40**
Module Code: PHYS5102	**Theory Paper Marks: 60**
Lecture: 4 Tutorial: 1	**Total Marks: 100**
Credit: 4.5	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Genera abstract mathematical formalism of quantum mechanics
- Schrodinger and Heisenberg's picture of quantum dynamics
- Angular momentum, its commutation relation and addition of angular momenta

Course Contents:

Unit 1: General formalism of quantum mechanics

States and operators; Representation of States and dynamical variables; Linear vector space; Bra Ket notation; Orthonormal set of vectors, Completeness relation; Linear operators; Eigen values and eigen vectors; Hermitian operators and their eigenvalues and eigenvectors; Commuting operators; Simultaneous eigenstates of commuting operators;The fundamental commutation relation; Generalized uncertainty relation; Matrix representation of an operator; position and momentum representation; Connection with wave mechanics; Change of basis and unitary transformation; Dirac delta function.

Unit 2: Quantum dynamics and symmetries in quantum mechanics

Schrodinger and Heisenberg's pictures of quantum dynamics; Heisenberg equation of motion and its classical limit. Solution of harmonic oscillator problem by operator method; Expectation value of an operator; Ehrenfest theorem; General view of symmetries in quantum mechanics; Continuous and discrete symmetries; Parity.

Unit 3: Angular momentum operator:

Angular momentum operators and their representation; Commutation relations among Lx, Ly and Lz ; Eigen values and eigenvectors of L_2, L_z , S_2 and S_z ; Eigenvalues of J_2 and Jz and their matrix representation; Ladder operators and their matrix representation; Pauli spin matrices; Addition of angular momentum; C G coefficients.

Unit 4: Solution of schrodinger equation

Solution of harmonic oscillator; eigenvalues eigenfunctions; Degeneracy of the states; Solution of the hydrogen atom problem, the eigenvalues eigenfunctions; Degeneracy of Energy levels.

Text Books:

1. Quantum Mechanics: Ghatak and Loknathan
   Tata McGraw Hill, New Delhi
2. Quantum Mechanics (Volume I and II): Claude Cohen-Tanoudji
   John Wiley and Sons
3. Modern Quantum Mechanics: J J Sakurai
   Addison Wesley, New York
4. Quantum Mechanics: Mathews and Venkatesan
   Narosa Publication, New Delhi
5. Quantum Mechanics: Eugen Merzbacher
   Wiley, Singapore

Faculty of Physical Sciences
Department of Physics
M Sc Physics (1st Semester)
Physics Core

Module: Nuclear and Particle Physics	**Sessional Marks: 40**
Module Code: PHYS5103	**Theory Paper Marks: 60**
Lecture: 4 Tutorial: 1	**Total Marks: 100**
Credit: 4.5	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Static properties of nuclei, two nucleon systems and nuclear force
- Various nuclear models
- Nuclear decays and nuclear reactions
- Elementary particles, their classification and properties
- Quarks, their classification. Standard model

Course Contents:

Unit 1: Two nucleon problem and nuclear forces

Static properties of Nuclei: Nuclear size from electron scattering; Nuclear form factors; Angular momentum, spin and moments of nuclei. Two nucleon systems and Nuclear forces: The deuteron: binding energy, dipole and quadrupole moments; Central and non-central (Tensor) forces; Neutron-proton scattering; Exchange character, Nucleon-nucleon scattering: S -wave effective range theory; General form of nucleon -nucleon nuclear force; Spin dependence of nuclear force (ortho and para hydrogen), charge independence and charge symmetry of nuclear forces; Iso-spin formalism

Unit 2: Nuclear models

Liquid drop model; The shell model; Spin, parity and magnetic moment in extreme single particle model; Physical concepts of unified model; Nilson model

Unit 3: Nuclear decays and nuclear reactions

Nuclear decays: Alpha, Beta and Gamma decays; Selections rules; Fermi's theory of beta decay; Selection rules; Kurie plots; Comparative half lines; Fermi and Gamow -Teller transitions; Parity non-conservation in beta decay;

Nuclear reactions: Reaction cross section; Compound nuclear reactions and direct reactions; The optical model; Breit-Winger resonance formula for l=0

Unit 4: Elementary particles

Fundamental interactions in nature: Gravitational Electromagnetic, weak and Strong; Elementary particles and their classification; Leptons, Hadrons, Mesons, Baryons; Conservation Laws for Elementary Particles; Baryon, Lepton and Muon number, strangeness and hypercharge; Gelleman - Nishijima scheme; Quarks and their classification: Quark model; SU(2) and SU(3) symmetry groups and classification of hadrons; Symmetries Parities of subatomic particles, charge conjugation, Time reversal; Introduction to the standard model; Electro-weak interaction; W and Z bosons.

Text Books:

1. Nuclear Structure, Volume: A Bohr and B R
   Mottelson Benjamin, Reading A, UK
2. Introductory Nuclear Physics: Kenneth S Krane
   Wiley, New York
3. An Introduction to Nuclear and Particle Physics: B Martin
   Wiley, New York
4. Introduction to Elementary Particles: D Griffiths
   Academic Press, New Delhi
5. Introduction to High Energy Physics: P.H. Perkins
   Addison-Wesley, London
6. Nuclear Physics: B L Cohen
   Tata McGraw Hill, New Delhi

Faculty of Physical Sciences
Department of Physics
M Sc Physics (1st Semester)
Physics Core

Module : Electronic Devices	**Sessional Marks: 40**
Module Code: PHYS5104	**Theory Paper Marks: 60**
Lecture: 4 Tutorial: 1	**Total Marks: 100**
Credit: 4.5	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Transistors and their types
- Integrated circuits and their fabrication
- Photoelectric and other commonly used electronic devices
- Negative resistance devices

Course Contents:
Unit 1: Transistors
Bipolar junction Transistor(BJT); Transistor operating modes; Transistor action; Transistor biasing configurations and characteristics; Transistor ratings; The Ebers-Moll model; Field Effect Transistors (FET); Junction Field Effect Transistor(JFET); Metal Oxide Semiconductor Field Effect Transistor (MOSFET); FET Parameters.

Unit 2: Integrated circuits and their fabrications
Integrated Circuits: Integrated circuits and their types, analog and digital integrated circuits;
Fabrication of integrated circuits: Semiconductor Fabrication**;** Planar Technology; Fabrication of Monolithic, integrated circuits; Monolithic passive and active circuit components; Typical IC; Low Frequency Amplifier; New Technology Trend

Unit 3: Photo-electric and other electronic devices
Zener Diode; Power Diode; Photodiode; Light emitting diode (LED); Solar Cell; Piezo-electric Crystals; Diode Lasers, Condition for Laser Action, Optical Gain; Memory Devices: Transistor Register, Random Access Memory, Read Only Memory.

Unit 4: Negative resistance devices
Tunnel Diode, Backward Diode, Uni-junction Transistor, p-n-p-n devices, p-n-p-n characteristics Thyristor, Silicon Controlled switch, SCS Characteristics, L Addition four Layer Devices. Basic Circuit Principles for NR Switching Circuits: Mono stable, By stable and A stable Operations.

Text Books:

1. Semiconductor Devices - Physics and Technology: S M Sze
   Wiley Publications, New York
2. Introduction to Semiconductor Devices: M S Tyagi
   John Wiley and Sons, New Delhi
3. Optical Electronics: Ajoy Ghatak and K Thygarajan
   Cambridge University Press, U K
4. Laser and Non-Linear Optics: B B Laud
   Wiley Eastern Limited, Singapore

Faculty of Physical Sciences
Department of Physics
M Sc Physics (1st Semester)
Physics Core

Module: Physics Lab-I
Module Code: PHYS5105
Practical: 8
Credit: 4.0

Sessional Marks: 40
Practical Exam Marks: 60
Total Marks: 100

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Performing the experiments related to two groups, namely electronics and nuclear physics
- Study of electronic devices, analog and digital circuits
- Study the characteristics of GM counter

List of Experiments:
Group 1: Electronics
Device Characteristics and Application
p-njunction diodes-clipping and clamping circuits; FET— characteristics, biasing and its applications as an amplifier; MOSFET — characteristics, biasing and its applications as an amplifier; UJT — characteristics, and its application as a relaxation oscillator; SCR — Characteristics and its application as a switching device.

Linear Circuits
Resonant circuits Filters-passive and active, all pass (phase shifters) Power supply-regulation and stabilization Oscillator-design and study Multi Stage and tuned amplifiers Multivibrators- astabie, monostable anc olstame Wim appiicanons Design and study of a triangular Wave generator Design and study of sample and hold circuits

Digital Circuits and Microprocessors
Combinational Sequential A/D and D/A converters Digital Modulation Microprocessor application

Group 2: Nuclear Physics
GM. Counters — characteristics, deadtime and counting statistics
Spark counter-characteristics and range of x-par’ricles in air
Scintillation detector~energy calibration, resolution and determination of gamma ray energy Solid State detector — surface barrier detector, its characteristics and applications.

Faculty of Physical Sciences
Department of Physics
M Sc Physics (2nd Semester)
Physics Core

Module: Atomic and Molecular Physics
Module Code: PHYS5106
Lecture: 4 Tutorial: 1
Credit: 4.5

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Atomic structure - Sommerfeld model of hydrogen atom
- Atomic spectra, doublet structure of alkali spectra
- Molecular structure-rotation, vibration and electronic structure of diatomic molecule
- Molecular spectra, symmetric top molecule

Course Contents:
Unit 1: Atomic structure
Bohr- Sommerfeld model of hydrogen atom and its short comings; Magnetic dipole and Vector model of an atom; Bohr magneton; Larmor precession; Space quantization and electron spin; Fine structure of hydrogen atonm; Mass correction, spin orbit and Darwin terms

Unit 2: Atomic spectra
Alkali spectra: Principal series; Theoretical interpretation of alkali series; Alkali-like spark spectra; Museley lines; Doublet structure of alkali spectra; Intensities of spectral lines; Selection rules for electric and magnetic dipole and multipole radiation; Forbidden transitions; Oscillator strength and Thomas-Rieche-Kuhn sum rule.; Ground state of two electron atoms-perturbation theory and variation method; Many electron atoms; LS and jj coupling schemes; Lande's interval rules; Hartree – Fock equations;

Unit 3: Molecular structure
Born-Oppenheimer approximation for a di-atomic molecule; Rotation, vibration and electronic structure of a di-atomic molecule; Molecular orbital theory and valence bond method for H_{2+} and H_2 molecule; Correlation diagrams for hetero-nuclear molecule.

Unit 4: Molecular spectra
Diatomic symmetric top; Rotation, vibration-rotation and electronic spectra of diatomic molecules; Franck-Condon principle; Electron spin and Hund's cases; Symmetry and point groups for diatomic and polyatomic molecules; Raman spectra

Text Books:
1. Atomic Spectra and Atomic Structure: G Hersberg
   Dover Publications, New York
2. Physics of Atoms and Molecules: B H Bransden and C J Joachain
   Pearson Education, UK
3. Introduction to Atomic Spectra: H E White
   Wiley Eastern, New Delhi
4. Spectra of Diatomic Molecule: G Hersberg
   Dover Publications, New York

Faculty of Physical Sciences
Department of Physics
M Sc Physics (2nd Semester)
Physics Core

Module: Quantum Mechanics-II	**Sessional Marks: 40**
Module Code: PHYS5107	**Theory Paper Marks: 60**
Lecture: 4 Tutorial: 1	**Total Marks: 100**
Credit: 4.5	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Approximation methods for time independent and time dependent problems
- Quantum theory of scattering
- Relativistic quantum mechanics

Course Contents:

Unit 1 Approximation methods for time independent problems

Time independent perturbation theory: Non degenerate case, the wave function and energy in first order; Delgarno and Lewis method; Anharmonic perturbations of the form ..x3 and ..x4' Zeeman effect; Degenerate case, stark effect of the first excited state of hydrogen. Variational method: Schrodinger equation as a variational equation; Estimation of ground state energy by variational method and comparision with perturbation theory; Ground state of Helium by variational method; The hydrogen molecule; WKB approximation.

Unit 2: Approximation method for time dependent problems

Time dependent perturbation theory: Constant perturbation; Harmonic perturbation; Transition to continuum of states; Transition probability; Fermi's golden rule; Adiabatic and sudden approximation; Semi classical theory of radiation: Transition probability for absorption and induced emission ; Electric dipole transition and selection rules; Magnetic dipole transitions; Forbidden transitions

Unit 3: Quantum theory of Scattering

Wave packet description of scattering; Formal treatment of scattering by Green's function; Born approximation; Differential and total scattering cross-section; Scattering by spherically symmetric potentials; Partial wave analysis; Optical theorem

Unit 4: Relativistic quantum mechanics

Klein Gordon and Dirac equation; Dirac matrices and their properties; Plane wave solutions to Dirac equation; Interpretation of negative energy solutions.

Text Books:

1. Quantum Mechanics: Ghatak and Loknathan
   Tata McGraw Hill, New Delhi
2. Quantum Mechanics (Volume I and II): Claude Cohen-Tanoudji
   John Wiley and Sons
3. Modern Quantum Mechanics: J J Sakurai
   Addison Wesley, New York
4. Quantum Mechanics: Mathews and Venkatesan
   Narosa Publication, New Delhi

Faculty of Physical Sciences
Department of Physics
M Sc Physics(2nd Semester)
Physics Core

Module: Electromagnetic Theory	**Sessional Marks: 40**
Module Code: PHYS5108	**Theory Paper Marks: 60**
Lecture: 4 Tutorial: 1	**Total Marks: 100**
Credit: 4.5	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Covariant formulation of electrodynamics
- Relativistic charged particle dynamics in electro0magnetic field
- Radiation by localized oscillating charges and by an accelerated point charge
- Lagragian formulation of electrodynamics

Course Contents:

Unit 1: Covariant Formulation of Electrodynamics

Fundamental problem of electromagnetic theory; Scalar and vector potentials; Gauge transformations; Coulomb and Lorentz gauge; Review of special theory of relativity and its applications to electromagnetic theory, concept of invariant interval, light cone, event; Four vectors, contra-variant and covariant 4 vectors and their transformation laws; Lorentz transformations as 4 vector transformation; Tensors and their transformation rule; Electro-magnetic field tensor and transformation of electro-magnetic fields; Maxwell's equations in tensor form and their covariance.

Unit 2: Relativistic charged particle dynamics in electromagnetic fields

Motion in a uniform static electric and uniform static magnetic fields; Motion in crossed static and magnetic fields; Particle drifts (velocity and curvature drifts) in a non -uniform static magnetic field; Adiabetic invariance of magnetic moment of charged particle and principle of magnetic mirror.

Unit 3: Radiation by localized oscillating charges and accelerated point charge

Green's function for relativistic wave equation; radiation from localized oscillating chrge; Near and far zones; Multipole expansion, dipole and quadrupole radiation; Centre fed linear antenna; Radiation from an accelerated point charge; Lienard-Wiechert potentials; Power radiated from a point charge; Lienard formula and its non-relativistic limit (Larmor's formula); angular distribution of radiated power for linearly and circularly accelerated charges.

Unit 4: Lagrangian formulation of electrodynamics

Lagrangian for a free relativistic charged particle; Lagrangian for electro-magnetic field interacting with charged particle; Equation of motion (Maxwell's equations); Energy momentum tensor and related conservation laws

Text Books:

1. Classical Electrodynamics: J D Jackson
   Wiley Eastern, New Delhi
2. Classical Electrodynamics: S P Puri
   Narosa Publishing House, New Delhi
3. Theory of Firlds: L D Landau and E M Lifshitz
   Oxford, Perganom, UK
4. Classical Theory of Electromagnetic radiation: ED Marrion
   Wiley Eastern, New Delhi

Faculty of Physical Sciences
Department of Physics
M Sc Physics(2nd Semester)
Physics Core

Module: Modern Optics	**Sessional Marks: 40**
Module Code: PHYS5109	**Theory Paper Marks: 60**
Lecture: 4 Tutorial: 1	**Total Marks: 100**
Credit: 4.5	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Laser Optics, Basic Laser Theory, Laser beam propagation and characteristics
- Holography and transient effects
- Fiber Optics, propagation of light in optical fibres and optical fibre wave guide
- Nonlinear and Elements of quantum optics

Course Contents:

Unit 1: Laser optics

Basic Laser Theory: Historical background of laser, Einstein coefficients and stimulated light amplification: population inversion, creation of population inversion in three level and four level lasers. Basic Laser Systems: Gas Laser: CO_2 laser, Solid State Laser: Host material and its characteristics, doped ions, Nd: YAG laser, Liquid laser: Dye laser, Semiconductor laser. Laser Beam Propagation and characteristics: Laser beam propagation, properties of Gaussian beam, resonator, stability, various types of resonators, resonator for high gain and high energy lasers, Gaussian beam focusing; high directionality, mono-chromaticity, spatial and temporal coherence.

Unit 2: **Holography and transient effects**

Holography: Importance of coherence, Principle of holography and characteristics, recording and reconstruction, classification of hologram and application, non-destructive testing Transient effect: Principle of Q-switching, different methods of Q-switching, electro-optic Q-switching, Pockets cell

Unit 3: **Fiber Optics**

Introduction: Propagation of light through optical fiber, numerical aperture; Modes of propagation in an optical fiber; V-number; Classification of optical fibers on the basis of (i).refractive indices of core and cladding material and (ii)modes of propagation; Optical fiber waveguides: Dielectric slab waveguide, modes in the symmetric slab waveguide, TE and TM modes, modes in the asymmetric slab waveguide, coupling of the waveguide (edge, prism, grating), dispersion and distortion in the slab waveguide, integrated optics components (active, passive), optical fibre waveguides (step index, graded index, single mode), attenuation in fibre, couplers and connectors, LED, injection laser diode (double hetero-structure, distributed feedback)

Unit 4: Nonlinear and Elements of quantum optics

Origin of nonlinearity, susceptibility tensor, phase matching, second harmonic generation, methods of enhancement, frequency mixing processes, nonlinear optical materials.

Text Books:

1. Optics (4th Edition): Ajoy Ghatak
   Tata McGraw Hill Publishing Company Ltd. New Delhi
2. Introduction to Fiber Optics: Ajoy Ghatak and K Thyagarajan
   Cambridge University Press, Cambridge, U K
3. Lasers-Theory and Applications: K Thyagarajan and A K Ghatak
   Plenum Press, New York

Reference Books:

1. Principles of Holography: H M Smith
   Wiley Inter-science, New York
2. Principles of Optics: M Born and E Wolf
   Pergamon Press, Oxford
3. Fundamentals of Optics: F A Jenkins and H E White
   McGraw Hill Book Company, New York

Faculty of Physical Sciences
Department of Physics
M Sc Physics(2nd Semester)
Physics Core

Module: Physics Lab-II
Module Code: PHYS5110
Practical: 8
Credit: 4.0

Sessional Marks: 40
Practical Exam Marks: 60
Total Marks: 100

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Performing the experiments related to two groups, namely solid state physics and modern optics
- Measurement of resistivity, band gap, determination of carrier concentration
- Determination of transition temperature in ferrites and ferroelectrics
- Study of Raman scattering using laser

Course Contents:
Group 1: Solid State Physics
Measurement of resistivity — Four probe and van der Paw techniques; determination of band gap Measurement of Hall coefficient — determination of carrier concentration
Measurement of magneto resistance
Measurement of thermoelectric power
Measurement of minority carrier lifetime in semiconductors; Shockley experiment.
Phase Transitions and Crystal Structure
Determination of transition temperature in ferrites
Determination of transition temperature in ferroelectrics
Determination of transition temperature in high Tc superconductors Determination of transition temperature in liquid crystalline materials
Crystal structure determination by x-ray diffraction powder photograph method

Group 2: Modern Optics

1. Jamin's interferometer — refractive index affair
2. Study ofelliptically polarized light
3. Constant deviation spectrometer-fine structure of Hg spectral lines e/m or hyperfine structure using Febiy Perot's interferometer Band spectrum in liquids Raman scattering using a laser source Luminescence

Laser Based Experiments
Optical interference and diffraction Holography
Electro-optic modulation Magneto-optic modulation Acousto-optic modulation
Sound modulation of carrier waves

Note: The list of experiments given above should be considered as suggestive of the standard and available equipment. The teachers are allillOl'lZfiCl to add or delete from this list whenever considered necessary.

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Core

Module: Statistical Mechanics	**Sessional Marks: 40**
Module Code: PHYS6101	**Theory Paper Marks: 60**
Lecture: 4 Tutorial: 1	**Total Marks: 100**
Credit: 4.5	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Classical statistical mechanics, its postulates and different statistical ensembles
- Quantum statistical mechanics, its postulates and classical and quantum statistics
- Cluster expansion and Ising model
- Phase transitions of 1st and 2nd order, Landau theory of liquid helium

Course Contents:

Unit 1: Classical statistical mechanics

Phase space; Ensembles; Lowville theorem,; Statistical equilibrium; Postulates of classical statistical mechanics; Micro canonical ensemble; Derivation of thermodynamics; Equi-partition theorem; Classical ideal gas; Gibbs paradox; Canonical ensemble and energy fluctuations in it; Grand canonical ensemble and density fluctuations in it; Equivalence of canonical and grand canonical ensembles.

Unit 2: Quantum statistical mechanics

Postulates of quantum statistical mechanics; In-distinguishability and quantum statistics, identical particles and symmetry requirements; Maxwell-Boltzman, Bose Einstein and Fermi Dirac statistics; Bose- Einstein condensation; Thermal properties of ideal B.E. gas, energy and pressure of F-D gas; Electrons in metals; Thermionic Emission.

Unit 3:Cluster Expansion and Ising Model

Cluster expansion: Cluster expansion for a classical gas, Second virial coefficient

Ising model: Definition of Ising model; Ising Model in one dimension; Bragg- Williams approximation; Bethe-Peierls approximation.

Unit 4: Phase transitions and liquid helium

Phase transition: Formulation of the problem; Phase transitions of first and second order

Liquid helium: The λ-transition; Tisza's two fluid model; Landau theory of liquid helium.

Text Books:

1. Statistical Mechanic: Kerson Huang
   Wiley Eastern Private Ltd., New Delhi
2. A Text Book of Statistical Mechanics; 2nd Ed.
   Suresh Chandra & M.K. Sharma; Cbs publishers & distributers, New delhi
3. Statistical Mechanics: R K Patharia Wiley Eastern Private Ltd., New Delhi
4. Statistical Mechanics: L D Landau and E M Lifshitz
   Oxford, Pergamon, UK

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Core

Module: Computational Physics	**Sessional Marks: 20**
Module Code: PHYS6102	**Theory Paper Marks: 30**
Lecture: 2 Tutorial: 1	**Total Marks: 50**
Credit: 3.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Computer basics, operating systems and computer language
- Numerical integration, differentiation, root finding and curve fitting
- Numerical solutions of simultaneous equations, eigen values and eigen vectors
- Numerical solution of first and second order differential equations

Course Contents:

Unit 1: Computer basics, Operating systems; Unix and C++

Computer basics and operating systems; computer principles; basic ideas of operating system, DOS and its use (using various commands of DOS); Compilers; interpreters; Directory structure; File operators; Introduction to Unix and computer principles; basic ideas of operating system, DOS and its use (using various commands of DOS); Compilers; interpreters; Directory structure; File operators; Introduction to Unix and C++; Introduction to graphics (graph plots)

Unit 2: Numerical Integration, Differentiation, Roots of Equations and Curve Fitting

Numerical Integration: Trapazoidal rule; Simpson's rule; Gauss-quadrature and Gauss-Hermite
Numerical differentiation**:** Taylor Series method; Generalized numerical differentiation: truncation errors
Roots of Linear, Non -linear Algebraic and Transcendental Equations: Bisection, Secant and Newton -Raphson methods; Convergence of solutions; Curve Fitting: Principle of least square; Linear regression; Polynomial regression; Exponential and Geometric regression

Unit 3: Solution of Simultaneous Linear Equations, Eigen values and Eigen vectors

Gaussian Elimination method; Pivioting; Gauss- Jordan elimination method; Matrices as arrays of variable sizes; Addition and multiplication of matrices; Matrix inversion; Eigen values and Eigen vectors; Jacobi's method for symmetric matrix

Unit 4: Numerical Solution of First and Second order differential equations

Numertical Solution of First Order Differential Eqns: First o d Order Differential Eqns: rder Taylor Series method; Euler's method; Runge Kutta methods; Predictor corrector method; Elementary ideas of solutions of partial differential equations. Numerical Solutions of Second Order Differential Eqns: Initial and boundary value problems; Shooting methods

Text Books:

1. Introductory Methods of Numerical Analysis: C S
   Sastry Tata McGraw Hills, New Delhi
2. Computation Physics - An Introduction: Verma, Ahluwalia and Sharma
   Narosa Publications, New Delhi
3. Numerical Methods: J.B. Dixit

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Core

Module: Computational Physics Lab	**Sessional Marks: 15**
Module Code: PHYS6103	**Practical Exam Marks: 35**
Practical: 4	**Total Marks: 50**
Credit: 2.0	

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Computer basics, operating systems and computer language
- Numerical integration, differentiation, root finding and curve fitting
- Numerical solutions of simultaneous equations, eigen values and eigen vectors
- Numerical solution of first and second order differential equations

List of Experiments:

1. Numerical Integration (Trepezoidal rule, Simpson's rule, Gauss quadrature and Gauss Hermite)
2. Roots of Equations (Secant and Newton-Raphson's methods) and Curve Fitting
3. Solution of Simultaneous Linear Equations
4. Eigen values and Eigen vectors
5. Numerical Solution of First and Second order differential equations (Runge-Kutta)

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Module: Solid State Physics Theory	**Sessional Marks: 40**
Module Code: PHYS6201	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- **X-ray** diffraction, binding, defects and diffusion in solids
- Quantum treatment to vibrations in solids
- Electronic states in solids
- Motion of electrons in solids

Course Contents:
Unit 1: X-ray diffraction, binding, defects and diffusion in solids X-ray diffraction: Crystal as a 3-dimensional diffraction grating; Diffraction of x-rays by crystals, Bragg's law and Bragg's planes; X-ray diffraction methods for determination of crystal structure- powder and rotating crystal methods; Neutron and electron diffraction.

Binding in solids: Types of crystal binding; London theory of van- Der Waal forces, ionic bonding and Madelung constant
Defects in solids: Point defects-Schottky and Frankel defects; Concentration of Schottky and Frankel defects; Line defects and dislocations
Diffusion in solids: Ficks's law, diffusion constant, self-diffusion, colour centres and excitons.

Unit 2: Vibrations in Solids
Classical treatment, normal modes; Quantum treatment, phonons, an-harmonic effects; Thermodynamic properties related to phonons; Continuum approximation; Measurement of phonon frequencies and inelastic scattering; Scattering mechanisms-impurity and phonon scattering; Normal and Umklapp processes. Mobility of charge carriers and Seebeck coffecient

Unit 3: Electronic states in solids
Sommerfeld model; Thermodynamic properties due to free electrons; Band structure- basic concepts; Periodic potential; Bloch's theorem; Density of states; Nearly free electron approach and pseudo-potentials; Tight-binding and linear combination of atomic orbital method; Modern band structure methods

Unit 4: Motion of electrons in solids
Semiclassical model, band velocity, effective mass; Concept of electron, 'hole and open orbits. Effect of open orbits on electric and high magnetic fields; magnetoresistance. Experimental determination of Fermi surface, De-Haas - van Alphen effect, anomalous skin effect and cyclotron resonance

Text Books:

1. Solid State Physics: Neil W Ashcroft and N David Mermin
   McGraw Hill Education
2. Solid State Physics: S.O. Pillai. New Age Int. Publishers
3. Solid State Physics: Rita John; Mc Graw Hills
4. Principles of the Theory of Solids: J M Ziman
   Cambridge University Press, UK

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Module: Solid State Physics Lab
Module Code: PHYS6202
Practical: 8
Credit: 4.0

Sessional Marks: 30
Practical Exam Marks: 70
Total Marks: 100

Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Design of operational circuits
- Microprocessor / computer interfacing based designs of circuits

Course Contents: List of Experiments
Group A:
Design of operational circuits (linear and digital) using discrete and LC. component's

1. Design of phase sensitive detector
2. Design of digital filters
3. Design of multistage amplifiers
4. Design of oscillators
5. Design of wave shaping circuits.

Group B:
Microprocessor/computer interfacing using standard self wave and interfacing circuits for physics experiment s. (LV. characteristics, temperature controller etc.)

Note:
This list is tentative; changes in the list of experiments may be made, depending on the availability of the equipment and other relevant considerations. Interested students may be allowed to do project work.

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Module: Advanced Electronics Theory | **Sessional Marks: 40**
Module Code: PHYS6203 | **Theory Paper Marks: 60**
Lecture: 4 | **Total Marks: 100**
Credit: 4.0 | **Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Basic concepts of communication
- Linear systems and signal processing
- Digital systems and signal processing
- Fast fourier and wavelet transforms

Course Contents:

Unit 1: Basic Concepts in Communication

EM wave propagation; Transmission lines; Coaxial cable; Wave guide; Optical fiber and free space; Propagation of ground wave, space wave and surface waves; Sky wave transmission; Definition of characteristic impedance; Reflection coefficient; Standing wave ratio (microwave components) and measurement of impedance in various media

Unit 2: Linear Systems and Signal Processing

Signal and system; Linear time invariant systems; Fourier analysis for continuous time signals and systems; Modulation of signals (AM, single sideband modulation, angle modulation and pulse modulation); Noise - enhancement of SNR in instrumentation and communication Signal to noise ratio (SNR)

Unit 3: Digital Systems and Signal Processing

Discrete time signals and system; Z-transform; Sampling of signals in the time and frequency domain; Structures of finite impulse response (FIR) and infinite impulse response (UR); Filters

Unit 4: Fast Fourier and wavelet transforms

Discrete Fourier Transform; Fast Fourier Transform (DIT and DIF Algorithm); Wavelet transforms and signal processing

Text Books:

1. Electronic Communication (4th edition): Rudy and Cohlen
   Prentice Hall of India,
2. Electronic Communication System (4th edition): G Kennedy
   Tata Mc Graw Hill, New Delhi
3. Optical Communication Systems: John Gowar
   Prentice Hall of India
4. Digital Signal Processing: J G Proakins and D G Manolakis
   Prentice Hall, 2006)

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Module: Adv. Electronics Lab
Module Code: PHYS6204
Practical: 6
Credit: 3.0

Sessional Marks: 40
Practical Exam Marks: 60
Total Marks: 100

Course Objectives:

A study of the subject matter presented in this course will enable the students to become familiar with

- The obtaining of Laue photograph of a given crystal
- Use of powder method for determination of crystal structure and cell dimension
- Determination of Hall's coefficient

Course contents:

1. Set the c-axis of the given crystal perpendicular to the incident x-ray beam.
2. Obtain the Laue photograph of the given single crystal, draw gnomonic projection, and index the reflections.
3. Obtain an oscillation photograph of the given single crystal about c-axis and calculate the c dimension of the unit cell, and index the reflections.
4. Determine the cell dimensions and establish the face centering of copper by Debye-Scherrer method (Powder method)
5. Determine the value of the Hall coefficient for the given sample and calculate the value of the mobility of the carriers and the carrier concentration. (Transverse magneto-resistance coefficient is given)
6. Determine the transverse magneto-resistance coefficient and the resistivity for the given sample and calculate the value of the mobility of the carriers and the carrier concentration

Note:

This list is tentative; changes in the list of experiments may be made, depending on the availability of the equipment and other relevant considerations. Interested students may be allowed to do project work.

Faculty of Physical Sciences
Department of Physics
M Sc Physics
Physics Electives

Module: Nuclear Physics Theory
Module Code: PHYS6205
Lecture: 4
Credit: 4.0

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives:

A study of the subject matter presented in this course will enable the students to become familiar with

- Nuclear experimental techniques
- Detector techniques
- Gamma ray spectroscopy
- Doppler shift and Mossbauer effect

Course Contents:

Unit 1: Nuclear Experimental Techniques-Nuclear electronics and signal processing

Accelerator, Type of accelerators and their basic principle, accelerator facilities in world, Vacuum Techniques, Target and thin film preparation. Nuclear electronics and Signal processing- NIM, ECL and TTL standard, Data acquisition systems - CAMMAC and VME, Digital pulse processing (introduction only)

Unit 2: Detector Techniques Gas detector

Ionisation chambers, Proportional counter, Multi-Wire proportional Counters (MWPC), G.M.Counter, Scintillation Detectors: Nal('.l“l),CsI(Tl), BaF2, LaZBr3, Organic and Plastic Scintillators. Solid states Detectors: Si(Li), Ge(li), HPGe, Clover and segmented HPGe Detectors, Surface Barrier Detectors, Neutron Detectors

Unit 3: Gamma-ray spectroscopy

Charge particle, neutron and gamma-ray spectroscopy, methods for charge and mass identification; TOP; mass spectrometer, Neutron: TOP and n- discrimination, Gamma-rays: Coincidence technique, Detector array, Multiplicity, Angular Distribution and correlation, Brief ideas of multi -polarity and transition probabilities, Weiskorf-estimate, Internal conversion coefficient and their ratios, Polarization and its measurement.

Unit 4: Application of Nuclear Technique- Doppler shift and Mossbauer effect

Doppler shift and Doppler broadening; Methods for life time measurements; Delay coincidence, pulse beam (slope and centroid shift); Recoil distance and Doppler shift; Mossbauer effect and its applications

Text Books:

1. Radiation Detection and Measurement: G F Knoll
   John Wiley and Sons, Inc. Ed., New Delhi
2. Physics and Engineering of Radiation Detection: S N Ahmed
   Academic Press, NY
3. Techniques for Nuclear and Panicle Physics Experiments: W R Leo
   Springer-Verlag, Germany
4. Nuclear Physics, Principles and Applications: L S Lilly
   John Wiley and Sons, Inc, New Delhi

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Module: Nuclear Physics Lab
Module Code: PHYS6206
Practical: 8
Credit: 4.0

Sessional Marks: 40
Practical Exam Marks: 60
Total Marks: 100

Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Study of radioactive isotopes by thermal neutrons
- Absorption of gamma rays in material media at different energies
- Beta and gamma ray spectroscopy

List of Experiments

1. Study of radioactive isotopes by thermal neutron activation analysis (Neutron flux, growth of activity and measurements).
2. Determination of the absolute disintegration rate of natural 40 K source using UXZ source as a standard. Deduction of the partial beta-decay half life of 40 K.
3. Extraction of active Bromine by S Zilard-Chalmers process and determination of the decay
1. Half lives of 80 Br isomers.
4. Absorption of gamma-rays in material media at different energies.
5. Gamma-rays spectroscopy using a TI scintillation spectrometer (energy response, energy resolution and detection efficiency determination).
2. Beta-ray spectroscopy using an anthracene scintillation spectrometer (energy calibration and end-point energy measurement by Kurie-plot).
6. Study of angular distribution of Compton scattered gamma rays using a scintillation spectrometer and the deduction of total scattering cross-section.
7. Resolving time of a Rossi coincidence circuit by the method of random coincidence using scintillation detectors and measurement of absolute source strength.

Note:
This list is tentative; changes in the list of experiments may be made, depending on the availability of the equipment and other relevant considerations interested students may be allowed to do project work.

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Module: General Theory of Relativity and Cosmology	**Sessional Marks: 40**
Module Code: PHYS6207	**Theory Paper Marks: 60**
Lecture: 4 Tutorial: 1	**Total Marks: 100**
Credit: 4.5	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Mathematical tools of GTR
- Equation of motion of particles and Einstein field equations
- Singularities and black holes
- Energy momentum tensor and conservation laws in curved space

Course Contents:

Unit 1: Mathematical tools of GTR

Covariant and contra variant tensors; Metric tensor; Parallel displacement and covariant differentiation; Affine connection and its relation to metric tensor; Curvature tensor and its symmetries; Bianchi identities

Unit 2: Equation of motion of particles and Einstein field equation

Equality of gravitational and inertial masses; Equivalence principle; Principle of general covariance; Equation of motion of particles; Weak fields and Newtonian approximation; Time and distance in general theory; gravitational red and blue shifts, experimental verification; Einstein field equation; Schwarzschild solution; General orbits Constants of motion; Mach's principle; Radial motion towards centre

Unit 3: Singularities and Black holes

Nature of singularities; Black holes; Even horizon; Kruska] co-ordinates; Deflection of light; Precession of perihelion and radar echo; Standard, isotropic and harmonic coordinates; Parameterized post Newtonian formalism and status of observational verification

Unit 4: Energy-momentum tensor and conservation laws in curved space

Energy momentum tensor for a perfect fluid, equation of motion from field equation for equation for dust. Action principle for field equations. Conservation laws in curved space and pseudo energy tensor for gravitational field

Text Books:

l. Cosmology: Steven Weinberg
Oxford University, UK
2. Principles of Cosmology and Gravitation: M Berry
Cambridge University Press, UK
3. General Theory of Relativity: P A M Dirac
John Wiley, London
4. Theory of fields: L D Landau and E M Lifshitz
Pergamon, USA

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Course Title: Plasma Physics	**Sessional Marks: 40**
Paper Code: PHYS6208	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Plasma definition, properties and plasma parameters
- Microscopic description of plasma
- Kinetic theory and statistical description of plasma
- MHD and fluid description of plasma

Course Contents:

Unit 1: Plasma properties and parameters

Definition and properties of plasma; Range of plasma parameters; Degree of ionization; Thermal versus non-thermal plasmas; potentials; magnetization; Comparison of plasma and gas phase

Unit 2: Microscopic description of plasmas

Dynamics of a charged particle in crossed electric and magnetic fields; Particle drifts-curvature, gradient drifts; Controlled thermonuclear devices; Magnetically confined open and closed systems -linear pinch, mirror machine and Tokamak; Laser plasmas; Initially confined system

Unit 3: Kinetic theory and statistical description of plasmas

BBGKY. hierarchy of equations; BoltZinann-Vlasov equation; Equivalence of particle orbit theory and the Vlasov equation; Boltzmann and Landau collision integral; H—theorem; BGK model- Fokker-Planck term; Solution of Boltzmann equation (brief outline); Transport coefficients-electrical conductivity, diffusion

Unit 4: Magneto hydrodynamics (MHD) and fluid description of plasmas

Brief review of magneto-hydrodynamics; Moment equations. MHD and C, G.L. equations; Generalized Ohm's law; Flux conservation; Decay of fields. Pressure balanced and force free fields

Text Books:

1. Principles of Plasma Mechanics: Bishwanath Chakraborty
   Wiley Eastern Ltd, New Delhi
2. Introduction to Plasma physics: F F Chen
   Plenum Press, New York
3. Introduction to Plasma Physics: R J Goldston and PH Rutherford
   IOP, New York

Reference Books:

1. Principles of Plasma Physics: N A Krall and Trivelpiece San Fransisco Press
2. Physics of High temperature Plasmas (2nd edition): G Schimdt Academic Press, New York

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Course Title: Physics at nano-scale
Paper Code: PHYS6209
Lecture: 4
Credit: 4.0

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Basic features of free electron and band theory of solids
- Nano-scale and quantum confines systems
- Nano-materials, their classification and properties
- Fabrication of nano-materials

Course Contents:
Unit 1: Review of basic features of free electron theory and Band theory of solids:
Energy levels of an electron in an infinitely deep potential well; Electron in periodic potential and the idea of band structure; Density of states in bands and the variation of density of states with energy; Variation of density of states and band gap with size of crystals.

Unit 2: Nano-scale and quantum confined systems
Nanoscale; Beyond Moore's law; Length, energy and time scales; Concept of nanotechnology; Electron confinement in infinitely deep square well potential- concept of quantum well, quantum wire and quantum dot structures and artificial atoms; Electronic structure from bulk to quantum dot;. Electron states in direct and indirect gap semiconductors nano-crystals. Confinement in disordered and amorphous systems

Unit 3: Nano-materials, their classification and Properties Nano-materials and their classification: Grapheme and Carbon Nano-tubes (CNT); Mechanical Properties-Young's modulus, toughness and hardness; Structural Properties; Optical properties-metallic nano-particles, semiconductor nano-particles, quantum size effect, luminescence and electro-luminescence in semiconductor nano- particles; Magnetic properties-effect of magnetic field on nano-magnetic materials; Magnetic tunnel junction (MTJ); Reason for substantially different properties of nano-materials as compared to those at bulk scale- Volume to surface area ratio for nano-materials; Quantum confinement; Structure and thermodynamics at nanoscale; Crystalline phase transitions and geometric evolution of the lattice in nano crystals, thermodynamics of very small systems

Unit 4: Fabrication of nano-materials: Processing and fabrication -Top-down approach to nanolithography, immersion lithography, EUV photolithography; Phase shifting masks; X-ray lithography including plasma-X-ray sources; e-beam lithography and focused ion beams; Molecular Technique-Bottom-up approach; Chemical self-assembly, spontaneous formation and ordering of nanostructures; Production of CNT's;

Text Books:
1. Nanotechnology- Principles and Practices: Sulabha K Kulkarni
   Capital Publishing Company, New Delhi
2. Fundamentals of Nan0electronics: G W Hanson Pearson Education, New Delhi
3. Nanostructures-Theory & Modelling: C Delewe and M Launoo Springer, Verlag
4. Nanostructure: V A Shchukin, N N Ledcntsov and D Bimberg Springer, Verlag

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Module: Field Theory and Quantum Electrodynamics	**Sessional Marks: 40**
Module Code: PHYS6210	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- free fields and their quantization
- invariance principles
- Fynman propagators and invariance in gauge theories
- path integral formalism

Course Contents:
Unit 1: Free fields and their canonical quantization
Canonical fields as generalized coordinates; Action principle; Euler-Lagrange equations; Noether‘s theorem; Canonical quantization of free scalar, free spinor and free electromagnetic fields

Unit 2: Invariance principles
Lorentz invariance of free field theory; C, P, T and CPT transformations; Spin and statistics and related theorems

Unit 3: Feynman propagators and invariance in gauge theories
Normal and Time -ordered products, Covariant commutation relations and theory of Feynman propagators, Local and global invariance in Gauge theories

Unit 4: Path integral formalism
Path integral formulation: functional methods quantization.

Text Books:
1. Relativistic Quantum Mechanics: J D Bjorken and S Drell
   McGraw Hill, New York
2. Relativistic Quantum Fields: J D Bjorken and S Drell
   McGraw Hill, New York
3. Quantum Field Theory: C ltzykson and J B Zuber
   McGraw Hill, New York

Reference Books:
1. Introduction to Relativistic Quantum Field Theory: S Schweber
   Row, Peterson, New York
2. Quantum Field Theory: L H Ryder
   Cambridge University Press, UK

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Course Title: Advanced Mathematical Physics	**Sessional Marks: 40**
Paper Code: PHYS6211	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Abstract groups and their representation
- Continuous groups and their applications in physics
- Integral equations and their types
- Boundary value problems

Course Contents:
Unit 1: Abstract groups, mapping and representations
Abstract groups: Groups; Subgroups; Classes; Cossets; Factor groups; Normal subgroups; Direct product of groups; Examples- cyclic, symmetric, matrix groups
Mappings: Homomorphism; Isomorphism; Automorphism.
Representations: Reducible and irreducible representation; Unitary representations; Schur's lemma and orthogonality theorems; Characters of representation; Direct product of representations.

Unit 2: Continuous groups and their applications in physics
Lie groups; Rotation and unitary groups; Point groups; Translation and space groups; Representation of point groups; Introduction to symmetry group of the Hamiltonian

Unit 3: Integral equations
Integral equations and kernels; Conversion of ordinary differential equations into integral equations; Fredholm and Volterra integral equations; Separable kernels, Fredholm theory, eigenvalues and eigen functions

Unit 4: Boundary Value Problems
Dirichlet and Neumann boundary conditions; Self-ad joint operators; Sturm—Liouville theory, Green's function, eigen function expansion

Text Books:
1. Advanced Method of Mathematical Physics: R S Kaushal and D Parashar
   Narosa Publications, New Delhi
2. Mathematical Methods for Physicists: George B. Arfken and Hans J Weber
   Academic Press, New York
3. Elements of Group Theory for Physicists: A W Joshi
   John Wiley, New Delhi

Reference Books:
1. Group Theory and Its Applications to Physical Problems: Morton
   Hamermesh Dover Publications, UK

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Course Title: Advanced Solid State Physics
Paper Code: PHYS6212
Lecture: 4
Credit: 4.0

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Lattice dynamics
- Thermal neutron scattering and correlation functions
- Mossbauer's effect
- Green's function and the density of states

Course Contents:

Unit 1: Lattice dynamics

Lattice dynamics in 3-dimensions; Relationship between atomic force constants under various operations; Acoustic and optical modes; Normal modes. Quantization of lattice vibrations; Phonons; Zero-point energy; Quantum crystals; Stefan-Boltzmann law; Van Hove singularities; Lindemann melting criterion

Unit 2: Thermal neutron scattering and correlation functions

Theory of Thermal Neutron Scattering; Double differential scattering cross-section. Space-time dependent correlation functions and their properties. Dynamical structure factor of (i) a harmonic crystal, zero phonon and one phonon processes, (ii) non-interacting gas and (iii) a simple liquid.

Unit 3: Mossbauer Effect

Lamb-Mossbauer recoilless fraction; Atomic motions; Isomer shift; Quadrupole splitting and magnetic splitting; Second order Doppler shift

Unit 4: Green's function and density of states

Free electron Green's function and its Fourier transform; Relationship of free electron Green's function with the density of states; Green's function of a system subject to small perturbation; Rigid band model and other applications to alloys.

Text Books:

1. Solid State Physics: Gerald Bums
   Academic Press, New York
2. Quantum Theory of Solids (Part A and B):
   Callaway Academic Press, New York
3. Mossbauer Effect -Principles and Applications: G K Wertheim
   Academic Press, New York
4. Superconductivity: V LGinzburg and B A Andryushin
   World Scientific, Singapore

Reference Books:

1. Solid State Physics: Walter A Harrison Dover Publications, UK
2. The Mossbauer Effect: Hans Praunfelder W A Benjamin, UK

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Module Astronomy and Astrophysics	**Sessional Marks: 40**
Module Code: PHYS6213	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Astronomical coordinates and observational data
- Telescopes and instrumentation
- Sun and solar atmosphere
- Variable stars

Course Contents:

Unit 1: Observational Data

Astronomical. coordinates- Celestial Sphere, Horizon, Equatorial, Ecliptic and Galactic Systems of Coordinates, Conversion from one system of co-ordinates to another, Magnitude Scale- Apparent and absolute magnitude, distance modulus. Determination of mass, luminosity, radius, temperature and distance of a star, Color Index, Stellar classification Henry-Draper and modern M-K Classification schemes, H-R Diagram, H-R Diagram of Clusters, Empirical mass luminosity relation

Unit 2: Telescopes and Instrumentation

Different optical configurations for Astronomical telescopes, Mountings, plate scale and diffraction limits, telescopes for gamma ray, X-ray, UV, IR, mm and radio astronomy, Stellar Photometry - solid state, Photo-multiplier tube and CCD based photometers, Spectroscopy and Polarimetery using CCD detectors

Unit 3: Sun and solar atmosphere

Physical Characteristics of sun- basic data, solar rotation, solar magnetic fields, Photosphere - granulation, stin spots, Babcock model of sunspot formation, solar atmosphere — chromo sphere and Corona1 Solar activity- flares, prominences, solar wind, activity cycle, Helio-seismology

Unit 4: Variable Stars and Astero-seismology

Photometry of variable stars, differential photometry, extinction coefficients, Classes of variable stars, Period-Mean density relationship, Classical Cepheid's as distance indicators, pulsation Mechanisms.

Text Books:

1. Introduction to Astronomy and Cosmology: I Morrison
   Wiley Publications, New Delhi
2. An Introduction to Astronomical Photometry: E Budding
   Cambridge Univ. Press, UK
3. Fundamentals of Solar Astronomy: A Bhatnagar and W
   C Livingston World Scientific, Singapore

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Course Title: Particle Physics	**Sessional Marks: 40**
Paper Code: PHYS6214	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Elementary particles and their classification
- Relativistic dynamics of particles
- Classification schemes of elementary particles
- Path integral formalism

Course Contents:
Unit 1: Introductory survey of elementary particles
Nature of interactions, Characteristic life-times and strengths. Theory of beta. decay, muon decay, lepton conservation, Types of neutrinos.

Unit 2: Relativistic dynamics
Scalar, Dirac fermion and electromagnetic fields, Invariance principles, Lorentz invariance of free fields, Symmetry and conservation laws; Noether's theorem and its applications, Quantization of free fields C,P,T transformations and symmetry operations, properties of bilinear covariants under and T. llustrations and applications of CPT theorem, SU(2) iso-spin symmetry, G-parity.

Unit 3: Classification schemes for elementary Particles
Classification schemes for particles and resonances, Introductory quark physics, SU(3) cl assification

Unit 4: Path integral formalism
Weiner's Feynman measures; Concepts of paths; Functional method of field quantization

Text Books:

1. Introduction to Elementary Particles: D Griffiths
   2nd Ed., Wiley-_VCH
2. Quarks & Leptons: F Halzen and A D Martin
   John Wiley, New York
3. Elementary Particle Physics: S Gasiorowicz
   John Wiley, New Yor

Reference Books:

1. Elementary Particles and the Laws of Physics: R P Feynman and S Weinberg
   Cambridge University Press, UK
2. Introduction to Elementary Particle Physics: A Bettini
   Cambridge University Press, UK

Faculty of Physical Sciences
Department of Physics
M Sc Physics (3rd Semester)
Physics Electives

Course Title: Condensed Matter Physics
Paper Code: PHYS6215
Lecture: 4
Credit: 4.0

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Lattice dynamics
- Optical properties of solids
- Electron-phonon interaction
- Superconductivity

Course Contents:
Unit 1: Lattice Dynamics
Interatomic forces and lattice dynamics of simple metals, ionic and covalent crystals. Optical phonons and dielectric constants. Inelastic neutron scattering. Mossbauer effect. Debye - Waller factor. Anharmonicity, thermal expansion and thermal conductivity.

Unit 2: Optical Properties of Solids
Interaction of electrons and phonons with photons. Direct and indirect transitions. Absorption in insulators, Polaritons, one phonon absorption, optical properties of metals, skin effect and anomalous skin effect.

Unit 3: Electron-Phonon Interaction
Interaction of electrons with acoustic and optical phonons, polarons. Superconductivity: manifestations of energy gap. Cooper pairing due to phonons, BCS theory of superconductivity.

Unit 4: Superconductivity
Experimental survey; Effect of External magnetic field, critical magnetic field; Meissener's effect;; London's equations and explanation of Meissener's effect; Type-I and type- II superconductors; Elements of BCS theory; Cooper pairs; Ginzsburg - Landau theory and application to Josephson effect : d-c and a-c Josephson effects; macroscopic quantum interference; Elementary idea of high temperature superconductivity

Text Books:

1. Introduction to Solid State Theory: K L Madelung
   Academic Press, UK
2. Quantum Theory of Solid State: W Callaway
   Tata McGraw Hills, New Delhi

Reference Books:

1. Theoretical Solid State Physics: K Huang World Scientific, Singapore

Quantum Theory of Solids: C W Kittel Wiley Publications, New Delhi

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Solid State Physics Theory
Paper Code: PHYS6216
Lecture: 4
Credit: 4.0

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Dielectrics and ferroelectrics
- Optical properties of materials and polymers
- Superconductivity
- Magnetism in solids and Quantum Hall's effect

Course Contents:

Unit 1: Dielectrics and Ferroelectrics

Review of polar and non-polar dielectrics and their polarization; Dielectric constant and polarizability; Macroscopic electric field; Local electric field at an atom; Clausius-Mossotti equation; Ferro electricity, antiferro electricity; Phase transition; Piezoelectricity;
Ferro elasticity, electrostriction

Unit 2: Optical properties of materials and polymers

Optical Properties: Optical constants and their physical significance; Kramers — Kronig Relations; Electronic inter bond and intra bond transitions; Relations between Optical properties and band structure — color of material (Frenkel Excitons); Bond Structure determination from optical spectra- reflection, refraction, diffraction, scattering, dispersion, photoluminescence, Electro-luminescence

Unit 3: Superconductivity

Phenomenological theories of superconductivity; BCS theory; Two fluid and Pippard's theory; Flux quantization; BCS ground state and energy gap; Determination of energy gap Electron tunneling in various configurations; SQUID; High temperature superconductors

Unit 4: Magnetism in solids and quantum Hall effect

Magnetism: Review of dimagnetism, paramagnetism and ferromagnetism; Diamagnetic and paramagnetic susceptibility; Quantum theory of paramagnetism-unfilled electron shells; Hund's rules. Ferromagnetism, antiferromagnetism; Weiss molecular field model; Susceptibility above Curie temperature; Magnetisation below Tc; Domains, magnetic energy, Bloch walls, anisotropy energy. Hysteresis ~ soft and hard magnets; Magnetic force microscopy. **Quantum Hall Effect**: Integer quantum hall effect, two dimensional electron systems, Landau quantization and filling factor. Fractional quantum hall effect.

Text Books:

1. Solid State Physics: Neil W Ashcroft and N David Mermin
   McGraw Hill Education
2. Principles of the Theory of Solids: J M Ziman

3. Introduction To Superconductivity: M Tinkham
   Dover Publications, UK

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Solid State Physics Lab	**Sessional Marks: 40**
Paper Code: PHYS6217	**Practical Exam Marks: 60**
Practical: 8	**Total Marks: 100**
Credit: 4.0	

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Measurement of Hall's coefficient, conductivity and mobility at different temperature
- Calibration of a copper / silicon resistance thermometer and use it to measure the range of temperature

Course Contents:

1. Measure Hall coefficient, dc conductivity and mobility of a semiconductor at different temperatures (77 K to room temperature)
2. Determine the relaxation time (EPR) for a given sample and find the value of 'g'.
3. Determine the wavelength of the microwave output of a given reflex klystl-on oscillator and also to determine its repeller mode pattern.
4. Calibrate a cooper resistance thermometer and use it to measure temperature from 77 K to room temperature.
5. Calibrate a silicon resistance thermometer and use it to measure temperature from 77 K to room temperature.
6. Determine the specific heat of a given sample at room and liquid nitrogen temperature. Determine the Curie temperature of a given ferroelectric material.

Note: This list is tentative; changes in the list of experiments may be made, depending on the availability of the equipment and other relevant considerations. Interested students may be allowed to do project work.

Note: The end semester practical examination, including viva-voce, shall be held jointly by the teacher taking the laboratory course (called internal examiner) and an external examiner appointed by the Controller of Examinations.

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4^{th} Semester)
Physics Electives

Course Title: Advanced Electronics Theory
Paper Code: PHYS6218
Lecture: 4
Credit: 4.0
Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Semiconductor devices and their fabrication
- Microwave devices
- Photonic devices
- Memory devices and some special devices

Course Contents:
Unit 1: Semiconductor devices and their fabrication
Review of p-n junction; Metal-semiconductor and metal-oxide semiconductor junctions- BIT, FET, MESFET and MOSFET and their high frequency limits; Fabrication of Semiconductor Devices - Vacuum techniques, thin film deposition techniques, diffusion of impurities

Unit 2: Microwave devices
Tunnel diode; Transfer electron devices (Gumi diode); Avalanche transit time devices; Parametric devices; Vacuum tube devices-reflex kiysti on and magnetron

Unit 3: Photonic devices
Radiative transition and optical absorption; LED; Semiconductor lasers; Hetero structure and quantum well devices; Photo detector; Schottky barrier and p-n photo diode; Avalanche photodiode; Photo-multiplier tubes; Electro-optic and magneto-optic devices.

Unit 4: Memory devices and other devices
Volatile—static and D-RAM, CMOS and NMOS, non- volatiie-NMOS, ferroelecti'ic semiconductors, optical memories, magnetic memories, charge coupled devices (CCU); Piezoelectric; Pyroelectric and magnetic devices; SAW and integrated devices.

Text Books:

1. Semiconductor Devices: D K Roy
   Tata McGraw Hills, New Delhi
2. Semiconductor Devices Physics & Technology: S M Sze
   John Wiley, New Delhi

Reference Books:

1. Semiconductor Optoelectronic Devices: P Bhattacharya
   PHL-Inida
2. Microwave Devices & Circuits (3_{rd} edition): S Y Liao
   PHL India

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Advanced Electronics Lab
Paper Code: PHYS6219
Practical: 8
Credit: 4.0

Sessional Marks: 40
Practical Exam Marks: 60
Total Marks: 100

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Computer aided design using standard software for integrated circuits
- Electronic material and device fabrication (p-n junction diode, thin film sensors etc)

Course Contents:

Group A:
Computer aided design using standard software for integrated circuit and device fabrication.

Group B:
Electronic material and device fabrication and characterization (p-n junction, diffusion thin film sensors, optical memory etc)

Note: The end semester practical examination, including viva-voce, shall be held jointly by the teacher taking the laboratory course (called internal examiner) and an external examiner appointed by the Controller of Examinations.

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Nuclear Physics Theory	**Sessional Marks: 40**
Paper Code: PHYS6220	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Shell model of nucleus
- Collective model of nucleus
- Nuclear reactions
- Exotic nuclei

Course Contents:

Unit 1: Shell Model of nucleus

Review of shell Model, magic numbers, single particle shell model; Self~consistent approach- Hartee- Fock and Hartee, Fock and Bogaluibov; Quasi-particle, Seniority Scheme; M and J-scheme; Transformation from M-scheme to J – Scheme; D~Matrix;

Unit 2: Collective Model of Nucleus- Collective parameters; Rotational and Vibrational Spectra (brief derivation); Beta and Gamma vibration and bands; Nuclear moment of inertia; Models for normal and deformed nuclei- Nilsson Models and Nilsson Diagram, Shell correction**,** Particle Rotor Model-one, two and three particle

Unit 3: Nuclear Reactions: Types of reaction, Briet-Winger and Resonances, Direct reaction-elastic and inelastic scattering, Transfer reaction (semi-classical approach), Fusion, Break-up, coupled channels approach, Compound nuclear reaction and statistical models, Coulomb excitation and is applications;

Unit 4: Exotic Nuclei

Nuclear landscape and drip lines; Production of exotic nuclei and fragmentation technique; Super Heavy Element (SHE) production; Structure of exotic nuclei and application in astrophysics, break down of magic numbers in exotic shapes; Halo nuclei; Neutron skin, GDR and soft dipole resonance (reaction point of view)

Text Books:

1. Theory of Nuclear Structure: M K. Pal
   Affiliated East-west Press, New Delhi
2. Nuclear Structure from a Simple Perspective (2nd edition): R F Casten
   Oxford Univ. Press, UK
3. Nuclear Reaction and Nuclear Structure: P E Hodgson
   Clarendon Press, New York

Reference Books:

1. Theoretical Nuclear Physics (Vol.1 Nuclear Structure): DeShalit and Feshbach
   Wiley Inter science, New Delhi
2. Heavy ion reactions (Vol. I and II): R A Broglia and Aage Winther
   Benjamill/Cummings, 1981)

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Nuclear Physics Lab
Paper Code: PHYS6221
Practical: 8
Credit: 4.0

Sessional Marks: 40
Practical Exam Marks: 60
Total Marks: 100

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Energy determination of alpha particles in thorium decay
- Study of Mossbauer effect and evaluation of natural line width
- Determination of Lande's 'g' factor

Course Contents:

1. Study of fast-slow delayed coincidence system (resolving time as a function of clipping length, true-to-chance-ratio and coincidence efficiency).
2. Directional correlation measurements of cascading gamma rays and the determination of the cascade anisotropy using 60Co source.
3. Proportional counter, its energy response and low energy X-ray measurements.
4. Alpha spectroscopy using a Si surface-barrier detector (energy response, energy resolution and energy determination).
5. Energy determination of alpha particles emitted in the thorium decay using nuclear emulsion plates. '
6. Study of Mossbauer effect and evaluation of the natural line width. Measurement of the magnetic dipole moments ofthe 14.4 Ke'V state in D7Fe.
7. 'g' factor, proton NMR method using Ferric Nitrate Solution.

Note:
This list is tentative; changes in the list of experiments may be made, depending on the availability of the equipment and other relevant considerations Interested students may be allowed to do project work.

Note: The end semester practical examination, including viva-voce, shall be held jointly by the teacher taking the laboratory course (called internal examiner) and an external examiner appointed by the Controller of Examinations.

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: General Theory of Relativity and Cosmology
Paper Code: PHYS6222
Lecture: 4
Credit: 4.0

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Relativistic astrophysics
- Cosmology-maximally symmetric spaces, Hubble's constants
- Cosmology- closed, flat and open spaces, missing mass problem
- Gravitational radiation

Course Contents:

Unit1: Relativistic Astrophysics

Schwarzschild solution for star; Birkhoft's theorem; Oppenheimer, Volkov and Tolman equation: Metric of uniform density stars; Polytropic stars, their potential and kinetic energies and stability; Radial oscillations and maximum rotational frequency; White dwarfs; Neutron stars and pulsars; Stability of super massive stars; Kerr metric

Unit 2: Cosmology-maximally symmetric spaces, Hubble's constant

Cosmological principle; Maximally symmetric spaces; Killing vectors; Robertson-Walker metric; Red shift; Hubble's law; Magnitude red shift relation; Hubble's constant and declaration parameter

Unit 3: Cosmology- closed, flat and open spaces, missing mass problem

Einstein equation and standard models; Closed, flat and open universes; Age of the universe; Critical density and problems of missing mass or missing light; History of early universe; Helium formation; Decoupling of matter and radiation; Microwave background radiation

Unit 4: Gravitational Radiation

Weak field approximation and linear Wave equation; Plane waves, their polarization, helicity and energy momentum; Emission of radiation by a rotating source; Effect of radiation on a test particle; Detection of gravitational radiation

Text Books:

l. Cosmology: Steven Weinberg
Oxford University, U K

2. Principles of Cosmology and Gravitation: M Berry
Cambridge University Press, U K

Reference Books:

1. General Theory of Relativity: P A M Dirac John Wiley, London

Theory of fields: L D Landau and E M Lifshitz Pergamon, USA

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Plasma Physics
Paper Code: PHYS6223
Lecture: 4
Credit: 4.0

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Plasma oscillations
- Waves in plasma
- Plasma instabilities
- Collision processes in plasma

Course Contents:

Unit 1: Plasma oscillations

Small amplitude plasma oscillations. Oscillations in Warm field free plasma. Landau damping.

Unit 2: Waves in plasmas

Waves in un-magnetized plasma; Energy transport process; Negative and positive energy waves; Generalized Ohm's law; Waves in magnetized plasma; Alfven waves; Dissipative effect; Magneto-acoustic waves; Hydro-magnetic shocks; KDV equation. Linear and nonlinear ion-acoustic waves; Non-linear electrostatic waves,.BCK waves

Unit 3: Plasma instabilities

Penrose criterion of stability; Two stream stability (linear and quasi linear theory); Vlasov theory of magnetized plasma; Loss cone instability; Quasi-linear theory of gently bump instabilitygggggg; Magneto-hydrodynamic instabilities. Energy principle. Normal mode analysis and its application to Rayleigh-Tayler and Kelvin Helmholtz instabilities. Pinch instability. Firehose and mirror instabilities. Virial theorem and Jean's instability.

Unit 4: Collison processes in Plasmas

Review of two body elastic collisions-collision cross section and collision probability; Two particle coulomb interaction; Interaction in screened potentials; Diffusion and scattering; Relaxation processes; Collisions between electrons and neutral particles; Scattering of ions by electrons; Interactions of long and short range; plasma conductivity; collision process in ionosphere; Thomson scattering cross-section; Collision process in MHD generators

Text Books:

1. Principles of Plasma Mechanics: Bishwanath Chakraborty
   Wiley Eastern Ltd, New Delhi
2. Introduction to Plasma physics: F F Chen
   Plenum Press, New York
3. Introduction to Plasma Physics: R J Goldston and PH Rutherford
   IOP, New York

Reference Books:

1. Principles of Plasma Physics: N A Krall and Trivelpiece
   San Fransisco Press
2. Physics of High temperature Plasmas (2nd edition): G Schimdt
   Academic Press, New York

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Physics at Nano-Scale	**Sessional Marks: 40**
Paper Code: PHYS6224	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Synthesis of nano-materials
- Techniques for analysis / characterization of nano-materials
- Models of semiconductor quantum wells, quantum wires and quantum dots
- Application of nano-materials

Course Contents:

Unit 1: Synthesis of nano-materials

Physical methods: Mechanical methods-High energy ball milling, melt mixing; Methods based on evaporation-physical vapour deposition with consolidation, ionized cluster beam deposition, laser vapourization; Sputter deposition; DC and RF sputtering, ECR plasma deposition, Chemical vapour deposition (CVD); Ion beam techniques; Molecular beam epitaxy

Chemical Methods: Colloids and their interaction with medium; Growth of nano-particles; Synthesis of metal nano-particles, semi-conductor nano-particles by colloidal route; Langmuir-Blodgett method

Unit 2: Techniques for (analysis / characterization) of nano-(materials / particles)

Microscopes: Optical microscope; Electron microscope; Scanning Electron Microscope(SEM); Transmission Electron Microscope (TEM); Scanning Tunneling Microscope (STM); Atomic Force Microscope (AFM); Scanning near force optical microscopy.

Diffraction techniques: X-ray diffraction (XRD); Electron diffraction; Neutron diffraction; Small angle (X-ray and Neutron) scattering (SAXS and SANS)

Unit 3: Models of semiconductor quantum wells, quantum wires and quantum dots

Semiconductor heterostructures and quantum wells; Confinement models of two dimensional electron gas; Energy band transitions in quantum wells; Excitonic effects; Quantum wires and nano-wires; Quantum dots and nano-particles; Nano-wires, ballistic and spin transport

Unit 4: Applications of nano-Materials

Coulomb blockade and Single electron devices. Applications of nano-materials to optics; Nano-photonics and nano-optics; Electro-optic modulators, photonic sensors; Nano-electronic devices; Use of nano-technology in high energy batteries, quantum computing etc.

Text Books:

1. Nanotechnology- Principles and Practices: Sulabha K Kulkarni
   Capital Publishing Company, New Delhi
2. Fundamentals of Nan0electronics: G W Hanson Pearson Education, New Delhi

Reference Books:

1. Nanostructures-Theory and Modelling: C Delewe and M Launoo Springer, Verlag
2. Nanostructure: V A Shchukin, N N Ledcntsov and D Bimberg Springer, Verlag

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Field Theory and Quantum Electrodynamics
Paper Code: PHYS6225
Lecture: 4
Credit: 4.0

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Interacting fields
- Quantum electrodynamics and Feynman diagram technique
- Renormalization theory
- Abelian and non-abelian gauge fields, Yang-Mills fields

Course Contents:
Unit 1: Interacting fields
Interaction representation; S-matrix expansion; Wick's theorem; Calculation for the S-matrix by covariant perturbation theory or by functional methods

Unit 2: Quantum electrodynamics (QED) and Feynman diagrams
Feynman diagrams in configuration space and in momentum space; Calculation of QED first and second order processes and Feynman amplitudes; Compton scattering; Electron-electron scattering; Electron self energy and photon self energy diagrams; Electron scattering by an external field and Bremsstrahlung

Unit 3: Renormalization Theory
Degree of divergences in a diagram, divergent amplitudes, UV and IR divergences and regularization. Renormalization of charge and mass in second order. Second order radiative corrections of QED, photon self energy, electron self energy, external line renormalization and vertex modification, Ward-Takahashi identities. Lamb shift and anomalous magnetic moment of the electron

Unit 4: Gauge fields and Yang-Mills Theory
Interaction of non-Abelian gauge fields (Gauge interaction of other particles, self interaction of gauge bosons)

Text Books:

1. Reletivistic Quantum Mechanics: J D Bjorken and S Drell
   McGraw Hill, New York
2. Relativistic Quantum Fields: J D Bjorken and S Drell
   McGraw Hill, New York
3. Quantum Field Theory: C ltzykson and J B Zuber
   McGraw Hill, New York

Reference Books:

1. Introduction to Relativistic Quantum Field Theory: S Schweber Row, Peterson, New York
2. Quantum Field Theory: L H Ryder Cambridge University Press, U K

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Advanced Mathematical Physics	**Sessional Marks: 40**
Paper Code: PHYS6226	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Ordinary differential equations, integrable and non-integrable systems
- Non-linear differential equations, phase space analysis, discrete and coupled systems
- Partial differential equations and solitons
- Stochastic processes and chaos

Course Contents:

Unit 1: Ordinary differential equation (ODEs), integrable and non-integrable systems

Introduction to ordinary differential equations (ODEs)- linear and nonlinear; Systems of ODEs; Existence and uniqueness theorems; Conservative versus dissipative systems; Invariant curves and quasi periodicity; Review of KAM theorem; Integrable and non-integrable systems.

Unit 2: Non-linear differential equations, phase space analysis, discrete and coupled systems

Phase space analysis: phase portrait, linear stability, potential, fixed points, periodic orbits, limit cycles; Poincaré-Bendixson theorem; Lyapunov functions; Gradient systems; Bifurcations- saddle-node, local and global bifurcations; Center manifold and normal form; Structural stability;

Discrete systems: Poincare cross sections; Linear stability and cobweb analysis; Universality and renormalization; Logistic maps; Strange attractors: Unstable periodic orbits; chaotic motions; Characterization of strange motions; Fractal dimension; Fourier transform; Entropy and Lyapunov exponents; Cantor set and Koch curve.

Coupled systems: synchronization and riddling; Multi-stability; Introduction to pattern formation.

Unit 3: Partial differential equations (PDEs) and Solitons

Introduction to partial different equations: Linear and nonlinear PDEs; Diffusive and dispersive PDEs; Boundary value problems; Methods of separation of variables; Similarity and Backlund transformations

Soliton theory: periodic, cnoidal and solitary wave solutions of Korteweg-de Vries, Nonlinear Schroedinger and sine-Gordon equations; conserved densities

Unit 4: Stochastic Processes and Chaos

Stochastic versus deterministic: random variables and functions, different moments of random variables; Fokker-Planck equation; Unstable sets; Stochastic versus chaotic motions; Effect of noise in excitable systems

Text Books:

1. Advanced Methods of Mathematical Physics: R S Kaushal and D Parashar
   Narossa Publications, New Delhi
2. Nonlinear dynamics: Integrability, Chaos and Patterns: M Lakshmanan and S Rajasekar
   Springer-Verlag

Reference Books:

1. Solitons: An Introduction: P G Drazin and R S Johnson Cambridge Univ. Press
2. Nonlinear Science: Scott Oxford Univ. Press

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Advanced Solid State Physics	**Sessional Marks: 40**
Paper Code: PHYS6227	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Magnetic properties of solids-dia, para and ferromagnetism
- Superconductivity
- Quantum Hall's effect
- Landau theory of Fermi liquid, Bose-Einstein condensation

Course Contents:

Unit 1: Magnetic properties of solids- Dia and para magnetism

Orbital magnetic moment of electrons; Magnetization; Magnetic susceptibility; Classification of solids on the basis of their mahnetic susceptibility; Diamagnetism; Para-magnetism of atoms with permanent magnetic moment; Pauli's para-magnetism of conduction electrons

Unit 2: Manetic properties of solids- Ferro and anti ferro magnetism

magnetic exchange interaction; Heisenberg's model for ferro and antiferro -magnetic insulators; Magnons in ferro and antiferro-magnets and their contribution to specific heat; Stoner theory of ferro-magnetism; Second quantization; local moment formation in metals, brief discussion of Kondo effect and Heavy fermion systems

Unit 3: Superconductivity

Experimental survey; Transition temperature; Effect of magnetic field; Meissner effect, Type-I and type-II superconductors; Thermodynamics of superconductors; Electrodynamics of superconductors-London's equations and explanation of Meissener's effect; Flux quantization; Copper instability; BCS theory of superconductivity; Coulomb pseudo-potential; Strong coupling effects, Josephson effects; Ginzburg-Landau theory

Unit 4: Quantum Hall effect, Landau theory of Fermi liquid and B-E condensation

Integral and fractional quantum Hall effect; Electron in a strong magnetic field; Landau levels and their degeneracy; Simple explanation of IQHE; Landau theory of Fermi liquid; BoseEinstein condensation.

Text Books:

1. Solid State Physics: Gerald Bums
   Academic Press, New York
2. Quantum Theory of Solids (Part A and B):
   Callaway Academic Press, New York
3. Mossbauer Effect -Principles and Applications: G K Wertheim
   Academic Press, New York
4. Superconductivity: V L Ginzburg and B A Andryushin
   World Scientific, Singapore

Reference Books:

1. Solid State Physics: Walter A Harrison Dover Publications, U K
2. The Mossbauer Effect: Hans Praunfelder W A Benjamin, U K

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Astronomy and Astrophysics
Paper Code: PHYS6228
Lecture: 4
Credit: 4.0

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Stellar structure and evolution
- Compact objects
- Galaxies
- Overview of modern astronomy

Course Contents:
Unit 1: Stellar Structure and Evolution
Virial Theorem; Formation of Stars; Hydrostatic equilibrium; Integral Theorems on pressure, density and temperature; Homologous Transformations; Polytropic gas spheres — Lane Emden Equation and its solution; Energy generation in stars; P-P and C-N cycles; Radiative and Convection transport of energy; Equations of stellar structure and their solution; Evolution of stars of different masses, pre- and post main-sequence evolution

Unit 2: Compact objects
Fate of massive stars, Degenerate electron and neutron gases, White dwarfs » mass limit, mass-radius relation, Neutron stars and pulsars

Unit 3: Galaxies
The milky way Galaxy, Distribution of stars, Morphology, Kinematics, Interstellar medium, Galactic center. Classification of galaxies, Hubble sequence, Elliptical, Lentreculars and spiral galaxies and their properties, distribution of light and mass in galaxies. (9 Lectures)

Unit 4: Overview of Modern Astronomy
2 l-cin hydrogen line; Cosmic radio sources; Quasars; Gravitational lensing; Expansion of the Universe and determination of Hubble's constant; Gamma ray busters.

Text Books:
1. Stellar Structure and Evolution: R Kippenhahn and A Weigeit
   Springer, Berlin
2. Modern Astrophysics: Carrol and Ostlie
   Addison Wesley, New York
3. Textbook of Astronomy and Astrophysics: V. B. Bliatia
   Narosa Publication, New Delhi

Reference Books:
1. Principles of Stellar Structure (Vol. I and II) : J P Cox and R T Giuli Gordon and Breach, U K
2. An Introduction to the Study of Stellar Structure: S Chanrdrasekliar Dover, U K

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Particle Physics
Paper Code: PHYS6229
Lecture: 4
Credit: 4.0

Sessional Marks: 40
Theory Paper Marks: 60
Total Marks: 100
Duration of Examination: 3Hrs

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Abelian and non-abelian gauge theories
- Standard model
- Electro-weak interactions
- Quantum chromodynamics

Course Contents:

Unit 1: Abelian and Non-Abelian gauge theory
Conserved vector current hypothesis and related topics, Abelian and Non-Abelian gauge theory with examples

Unit 2: Standard Model
SU(2) X U(1) eleotro-weak theory; Two component left handed fermions; Weak isospin, hypercharge assignment; SU(2) X U(1) symmetry breaking via Higgs mechanism; Masses of vector bosons;

Unit 3: Electro-weak interactions
Weak charged and neutral currents; Coupling of W and Z- bosons with leptons and quarks; Gauge vs. mass eigen states; Calculation of processes like W-decay, neutrino~electron scatterings

Unit 4: Quntum Chromo-dynamics
General concepts; Electron-positron annihilation to hadrons, QCD corrections

Text Books:

1. Introduction to Elementary Particles: D Griffiths
   2nd Ed., Wiley-_VCH
2. Quarks and Leptons: F Halzen and A D Martin
   John Wiley, New York
3. Elementary Particle Physics: S Gasiorowicz

1. Elementary Particles and the Laws of Physics: R P Feynman and S Weinberg
   Cambridge University Press, U K
2. Introduction to Elementary Particle Physics: A Bettini
   Cambridge University Press, U K

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Condensed Matter Physics	**Sessional Marks: 40**
Paper Code: PHYS6230	**Theory Paper Marks: 60**
Lecture: 4	**Total Marks: 100**
Credit: 4.0	**Duration of Examination: 3Hrs**

Course Objectives: A study of the subject matter presented in this course will enable the students to become familiar with

- Crystal Physics
- X-ray crystallography
- Exotic solids
- Nano structured materials

Course Contents:

Unit1: Crystal Physics

External symmetry elements of crystals. Concepts of point groups. Influence of symmetry on Physical properties : Electrical conductivity. Space groups, derivation of equivalent point position (with examples from triclinic and monoclinic systems), experimental determination of space group. Principle of powder diffraction method, interpretation of powder photographs.

Unit 2: X-Ray Crystallography

analytical indexing: Ito's method. Accurate determination of lattice parameters - least-square method. Applications of powder method. Oscillation and Buerger's precession methods.; Determination of relative structure amplitudes from measured intensities (Lorentz and polarization factors), Fourier representation of electron density. The phase problem, Patterson function.

Unit 3: Exotic Solids

Structure and symmetries of liquids, liquid crystals and amorphous solids. Aperiodic solids and quasicrystals; Fibonaccy sequence, Penrose lattices and their extension to 3-dimensions. Special carbon solids; fullerenes and tubules ; formation and characterization of fullerenes and tubules. Single wall and multi-wall carbon tubules. Electronic properties of tubules. Carbon nanotubule based electronic based electronic devices.

Unit 4: Nano Structural Materials

Definition and properties of nano-structured materials. Methods of synthesis of nano-structured materials. Special experimental techniques for characterization nano-structured materials. Quantum size effect and its applications.

Text Books:

1. Introduction to Solid State Theory: K L Madelung
   Academic Press, U K
2. Quantum Theory of Solid State: W Callaway
   Tata McGraw Hills, New Delhi

Reference Books:

1. Theoretical Solid State Physics: K Huang World Scientific, Singapore
2. Quantum Theory of Solids: C W Kittel Wiley Publications, New Delhi

Faculty of Physical Sciences
Department of Physics
M Sc Physics (4th Semester)
Physics Electives

Course Title: Elective Project | **Internal Marks: 80**
Paper Code: PHYS6231 | **External Marks: 120**
Credit: 8.0 | **Total Marks: 200**

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1. Topic of the project would be decided by the Supervisor himself. However, it would be among one of the thrust areas out lined by the Department of Science and Technology (DST) and related to the industry.

2. The supervisor, after the extensive survey and in collaboration with industry (if possible) shall state the problem for the M. Sc. Dissertation.

3. M. Sc. Student shall devote his time for solving this problem (which ultimately may be published as research work.)

4. Project title and/or problem would be such that it can be extended at Ph. D level (if the student whishes to pursue his Ph. D.)

5. Finally, the project report would be submitted in the form of M. Sc. Dissertation.