MURSHIDABAD UNIVERSITY

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Memo No.- MU(R)/1/C/571/24 **Date: 10/12/2024**

NOTIFICATION

It is notified for information of all concerned that in terms of the provision of the Murshidabad University Act, 2018, and, in existing of his powers, of the said Act, the Vice-Chancellor has, by and order dated 09.12.2024 approved the syllabi of the subject Physics for semester wise programme of PG Course of study under this university, as laid down in the accompanying pamphlet.

Place: Berhampore
Date: 10.12.2024

Rajib Mukherjee
Registrar
Murshidabad University

Registrar
Murshidabad University

MURSHIDABAD UNIVERSITY
Estd-2021
Berhampore (W.B.)

MURSHIDABAD UNIVERSITY

Berhampore Murshidabad* West Bengal*

DEPARTMENT OF PHYSICS
2024-2025

CBCS Syllabus for Two Years M.Sc. in Physics

CBCS curriculum for Semesterized Post-Graduate Course in Physics

Semester and Coursewise credit distribution in M.Sc. Physics under C.B.C.S

COURSE STRUCTURE OF SEMESTER-I

SEM	Course Name	Course Code	Course details	Marks	Credit
I	Mathematical Methods of Physics	PG-PHS-CC-101	CC-1	50 (End SEM-40+ Internal-10)	4
	Classical Mechanics and Non Linear Dynamics	PG-PHS-CC-102	CC-2	50 (End SEM-40+ Internal-10)	4
	Quantum Mechanics – I	PG-PHS-CC-103	CC-3	50 (End SEM-40+ Internal-10)	4
	Electrodynamics	PG-PHS-CC-104	CC-4	50 (End SEM-40+ Internal-10)	4
	General Physics Practical-I	PG-PHS-CC-105(P)	CC-5	50 (End SEM-50)	4

COURSE STRUCTURE OF SEMESTER-II

SEM	Course Name	Course Code	Course details	Marks	Credit
II	Statistical Mechanics	PG-PHS-CC-201	CC-6	50 (End SEM-40+ Internal-10)	4
	Solid State Physics	PG-PHS-CC-202	CC-7	50 (End SEM-40+ Internal-10)	4
	Nuclear and Particle Physics	PG-PHS-CC-203	CC-8	50 (End SEM-40+ Internal-10)	4
	Electronics	PG-PHS-CC-204	CC-9	50 (End SEM-40+ Internal-10)	4
	General Physics Practical-II	PG-PHS-CC-205(P)	CC-10	50 (End SEM-50)	4

COURSE STRUCTURE OF SEMESTER-III

SEM	Course Name	Course Code	Course details	Marks	Credit
III	Atomic, Molecular and LASER Spectroscopy	PG-PHS-CC-301	CC-11	50 (End SEM-40+ Internal-10)	4
	Quantum Mechanics -II	PG-PHS-CC-302	CC-12	50 (End SEM-40+ Internal-10)	4
	Discipline Specific Elective-I (Electronics)	PG-PHS-DSE-303(A)	DSE-1*	50 (End SEM-40+ Internal-10)	4
	Discipline Specific Elective-I (Solid State Physics)	PG-PHS-DSE-303(B)	DSE-1*	50 (End SEM-40+ Internal-10)	
	Discipline Specific Elective-I (Nuclear and Particle Physics)	PG-PHS-DSE-303(C)	DSE-1*	50 (End SEM-40+ Internal-10)	
	Applied Physics-I (General Elective)	PG-PHS-GE-322	GE**	50 (End SEM-40+ Internal-10)	4

	Advanced Physics Practical-I	PG-PHS-CC-304(P)	CC-13	50 (End SEM-50)	4

COURSE STRUCTURE OF SEMESTER-IV

SEM	Course Name	Course Code	Course details	Marks	Credit
IV	Discipline Specific Elective-II (Electronics)	PG-PHS-DSE-401(A)	DSE-2*	50 (End SEM-40+ Internal-10)	
	Discipline Specific Elective-II (Solid State Physics)	PG-PHS-DSE-401(B)	DSE-2*	50 (End SEM-40+ Internal-10)	4
	Discipline Specific Elective-II (Nuclear and Particle Physics)	PG-PHS-DSE-401(C)	DSE-2*	50 (End SEM-40+ Internal-10)	
	Applied Physics	PG-PHS-CC-402	CC-14	50 (End SEM-40+ Internal-10)	4
	Advanced Physics Practical-II	PG-PHS-CC-403(P)	CC-15	50 (End SEM-50)	4
	Project	PG-PHS-CC-404(P)	CC-16	50 (End SEM-40+ Internal-10)	4
	Grand Viva	PG-PHS-CC-405(P)	CC-17	50 (End SEM-50)	4

*DSE-Discipline Specific Elective

**GE -General Elective Course

(**Same DSE Paper should be taken by the students in SEM-III and SEM-IV**)

CBCS curriculum for Semesterized Post-Graduate Course in Physics

SEMESTER-I

MURSHIDABAD UNIVERSITY

Paper Code: PG-PHS-CC-101
Topic name: MATHEMATICAL METHODS OF PHYSICS
(50 marks=40 End SEM Exam+10 Internal) (4 credits)
(40 Lecture hours)

- ***Vector space and matrices:***

Vector space: Axiomatic definition, linear independence, bases, dimensionality, inner product; Gram-Schmidt orthogonalization.

Matrices: Representation of linear transformations and change of base; Eigenvalues and Eigen vectors; Functions of a matrix; Cayley-Hamilton theorem; Commuting matrices with degenerate eigenvalues; Orthonormality of eigenvectors. **[7 lecture hours]**

- **Complex analysis:**

Recapitulation: Complex numbers, triangular inequalities, Schwarz inequality. Function of a complex variable - single and multiple-valued function, limit and continuity; Differentiation; Cauchy-Riemann equations and their applications; Analytic and harmonic function; Complex integrals, Cauchy's theorem (elementary proof only), converse of Cauchy's theorem, Cauchy's Integral Formula and its corollaries; Series - Taylor and Laurent expansion; Classification of singularities; Branch point and branch cut; Residue theorem and evaluation of some typical real integrals using this theorem. **[12 lecture hours]**

- **Theory of second order linear homogeneous differential equations:**

Singular points - regular and irregular singular points; Frobenius method; Fuch's theorem; Linear independence of solutions - Wronskian, second solution. Sturm-Liouville theory; Hermitian operators; Completeness.

[5 lecture hours]

- **Inhomogeneous differential equations : Green's functions Special functions:**

Basic properties (recurrence and orthogonality relations, series expansion) of Bessel, Legendre, Hermite and Laguerre functions. **[3 lecture hours]**

- **Group theory:**

Definitions; Multiplication table; Rearrangement theorem; Isomorphism and homomorphism; Illustrations with point symmetry groups; Group representations: faithful and unfaithful representations, reducible and irreducible representations; Lie groups and Lie algebra with SU(2) as an example. **[10 lecture hours]**

- **Integral transforms**

Fourier and Laplace transforms and their inverse transforms, Bromwich integral [use of partial fractions in calculating inverse Laplace transforms]; Transform of derivative and integral of a function; Solution of differential equations using integral transforms. **[3 lecture hours]**

Recommended Books:

1. G. Arfken: Mathematical Methods for Physicists
2. J. Mathews and R.L. Walker : Mathematical Methods of Physics
3. P. Dennery and A. Krzywicki: Mathematics for Physicists
4. M.R. Spiegel: Theory and Problems of Complex Variables
5. A.W. Joshi: Matrices and Tensors in Physics
6. A.W. Joshi: Elements of Group Theory for Physicists

Paper code: PG-PHS-CC-102
Topic name: CLASSICAL MECHANICS AND NON-LINEAR DYNAMICS
(50 marks=40 End SEM Exam+10 Internal) (4 credits)
(40 Lecture hours)

- **An overview of the Lagrangian and Hamiltonian formulation:**

Problems involving systems with non-holonomic constraints; Review of Lagrangian and Hamiltonian formulation in different systems; Lagrangian and Hamiltonian for relativistic particles; Legendre transformation; Hessian determinant; Hamilton's canonical equations and their applications; Hamilton's action and the principle of least action. **(6 Lecture hours)**

- **Hamilton-Jacobi Theory:**

Hamilton-Jacobi equation for Hamilton's principal and characteristics functions; Physical significance of these functions; Application of Hamilton-Jacobi equation in linear harmonic oscillator, particle falling under gravity etc; Action and angle variables; Importance of action-angle variables; Applications of action-angle variables; Canonical perturbation theory. Passage from classical to quantum mechanics.

(8 lecture hours)

- **Canonical Transformation:**

Equations of point and Canonical transformations; generating functions; examples of canonical transformation; Integral variants of Poincare; generators of infinitesimal canonical/symmetry transformation; Noether's theorem, Lagrange and Poisson brackets and their applications; Invariance of Poisson bracket under canonical transformation; Equations of motion in Poisson Bracket; Conservation theorems, Jacobi's identity and angular momentum relations in Poisson brackets; Liouville's theorem.

(7 lecture hours)

- **Rigid Body Dynamics:**

Degrees of freedom; Euler angles, Euler's theorem on the motion of a rigid body, Infinitesimal rotation; Moments of inertia; Eigenvalues of the inertia tensor and principal axes transformations; Lagrange's equations of motion for a rigid body; Euler's equations of motion. Heavy symmetrical top with one point fixed; Precession and nutation; Larmor precession; gyroscope and asymmetrical top. **(8 lecture hours)**

- **Theory of Small Oscillations:**

Formulation of the problem; Eigenvalue equations; Frequencies of free vibrations and normal coordinates; forced vibrations and the effect of dissipative forces; Simple examples. **(3 lecture hours)**

- **Non-linear Dynamics and Chaos:**

Non-linear differential Equations: autonomous systems; Critical points; Stability; Limit cycles; Lienard theorem. Phase trajectories (Singular points and linear systems) Damped harmonic oscillator and overdamped motion; Poincare theorem; Bifurcations in various forms; Attractors; Chaotic trajectories; Non-linear Oscillation and Chaos. **(8 lecture hours)**

Books Recommended:

1. Goldstein, Poole and Safko: Classical Mechanics– Addison Wesley/Narosa.
2. L. D. Landau and E. M. Liftshitz, Mechanics (Course of theoretical Physics, Volume – I), Butterworth Heinemann (1982).
3. Sommerfeld: Mechanics – Academic Press.
4. Rana and Joag: Classical Mechanics – Tata-McGraw Hill.
5. Whittaker: Analytical Dynamics of Particles and Rigid Bodies – Cambridge.
6. Fetter and Walecka: Theoretical Mechanics of Particles and Continua - McGraw Hill.
7. A. K. Raychaudhuri: Classical Mechanics – Oxford.
8. Simmons: Differential Equations – Tata-McGraw Hill.

9. Bhatia: Classical Mechanics– Narosa.

11. Steven H. Strogatz, Nonlinear Dynamics and Chaos, CRC Press (2018).

12. Stephen Wiggins, Introduction to Applied Nonlinear Dynamical Systems and Chaos, Springer-Verlag (2003).

13. D. Jordan and P. Smith, Nonlinear Ordinary Differential Equations: An Introduction for Scientists and Engineers, Oxford University Press (2007).

Paper code: PG-PHS-CC-103
Topic name: QUANTUM MECHANICS-I

(50 marks=40 End SEM Exam+10 Internal) (4 credits)
(40 Lecture hours)

- **Recapitulation of basic concepts:**

Eigenvalues and Eigenfunctions; Commutativity and simultaneous eigenfunctions; Complete set of eigenfunctions. Expectation values; time dependence of expectation values of observables; Ehrenfest theorem; Probability density; Equation of continuity and probability current density.
[**5 Lecture hours**]

- **Operator method in quantum mechanics:**

Linear vector space; States and observables of a system as vectors and operators; Concept of Ket and Bra vectors; Uncertainty principle for two canonically conjugate operators using the concept of expectation value; One dimensional harmonic oscillator by operator method; Coherent states; Density matrix; Its properties and uses with examples. [**9 Lecture hours**]

- **Representations in quantum mechanics:**

Introduction to Schrodinger, Heisenberg and interaction pictures; Equation of motion in the three representations; Time translation operator.
[**3 Lecture hours**]

- **Three dimensional problems**:

Three dimensional well and Fermi energy; Three dimensional harmonic oscillator, eigenvalues by series solution. [**4 Lecture hours**]

- **Angular momentum:**

Angular momentum algebra; Raising and lowering operators; representation for j=1/2 and j=1; Addition of two angular momentum – Clebsch-Gordan coefficients, examples. [**6 Lecture hours**]

- **Stationary state problems:**

Bound and scattering states; One dimensional examples: Infinitely deep potential well, Delta-function potential, Kronig-Penney potential, Reflection and Transmission from step potential and potential barrier.

[7 Lecture hours]

- **Time dependent Schrodinger equation:**

Initial value problems; Greens function; concept of propagator; free particle moving in space. [**3 Lecture hours**]

- **Approximation method:**

Variational method for stationary state problems; simple applications.

[3 Lecture hours]

Reference Books:

1. S. Gasiorowicz : Quantum Physics
2. J. J. Sakurai : Modern Quantum Mechanics
3. E. Merzbacker ; Quantum Mechanics
4. B. H. Bransden and C. J. Joachain : Introduction to Quantum Mechanics
5. David Griffiths : Introduction to Quantum Mechanics
6. R. Eisberg and R. Resnick : Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles
7. Nouredine Zettili : Quantum Mechanics: Concepts and Applications
8. C. Cohen – Tannoudji, B. Diu and Frank Labe : Quantum Mechanics
9. L. I. Schiff : Quantum Mechanics
10. Prabir Ghosh: Quantum Mechanics

Paper code: PG-PHS-CC-104
Topic name: ELECTRODYNAMICS

(50 marks=40 End SEM Exam+10 Internal) (4 credits)
(40 Lecture hours)

- **Review of Maxwell's Equations:**

Fundamental problem of electromagnetic theory. Scalar and vector potentials. Gauge transformations. Coulomb and Lorentz gauges. Review of Special Theory of Relativity (STR) and its application to electromagnetic theory : Conceptual basis of STR. Thought experiments. Concepts of invariant interval, light cone, event and world line. Four-vectors, Tensors. Lorentz transformation as 4-vector transformations. Transformation properties of electric and magnetic fields. **(15 lecture hours)**

- **Relativistic Charged Particle Dynamics in Electromagnetic Fields:**

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

(5 Lecture hours)

- **Radiation:**

Green function for relativistic wave equation. Radiation from localized oscillating charges. Near and far zone fields. Multipole expansion. Dipole and quadrupole radiation. Centre- fed linear antenna. Radiation from an accelerated point charge. Lienard-Wiechert potentials. Power radiated by a point charge : Lienard's formula and its nonrelativistic limit (Larmor's formula). Angular distribution of radiated power for linearly and circularly accelerated charges. **(15 Lecture hours)**

- **Lagrangian Formulation of Electrodynamics:**

Lagrangian for a free relativistic particle, for a charged particle in an E.M. field, for free electromagnetic field, for interacting charged particles and fields. Energy-momentum tensor and related conservation laws. **(5 Lecture hours)**

Outcome:

A student having taken this course is expected to have a fair degree of familiarity with tensors and tensorial formulation of relativity and electrodynamics. In addition, s/he is expected to be able to solve problems of motion of charged particles in various field formations as well as find the radiation patterns from different time varying charge and current densities.

Reference books:

1. Introduction to Electrodynamics by David Griffiths (3rd Ed., Benjamin Cummings, 1999)
2. Classical Electrodynamics by John David Jackson (3rd Ed..,Wiley,1998)
3. Principles of Electrodynamics by Melvin Schwartz (Dover Publications, 1987)
4. Classical Electrodynamics by J. Schwinger, L.L. Deraad Jr, K.A. Milton, W-Y. Tsai and J. Norton (Westview Press, 1998)
5. Modern Problems in Classical Electrodynamics by Charles A. Brau (Oxford Univ. Press, 2003)
6. Electrodynamics of Continuous Media by L. D. Landau and E. M. Lifshitz & L. P. Pitaevskii (Oxford, 2005)
7. Electromagnetic Theory by J. A. Stratton (New York ; London : McGraw-Hill Book Company, Inc., 1941)
8. Introduction to Principles of Electromagnetic Theory by W. Hauser (Addison-Wesley, 1971)
9. Electromagnetic Theory by A K Raychaudhuri (Oxford University Press, 1990)

Course Code: PG-PHS-CC-105(P)

Topic name: GENERAL PHYSICS PRACTICAL-I

(50 marks) (4 credits)

1. Plotting of functions and data fitting etc. using Gnuplot.
2. Revision of numerical methods for
   - (a) Integration,
   - (b) Finding roots of equation
   - (c) Solving simultaneous linear differential equations
   - (d) Least square fitting
   - (e) Interpolation
   - (f) Solving differential equations using Euler method.
3. Use standard subroutines:
   - (a) Runge-Kutta method for solving differential equations– ex. Anharmonic oscillator.
   - (b) Matrix diagonalization – eigenvalue problem.
   - (c) Matrix inversion.
4. Monte Carlo methods: Applications in
   - (a) Random number generation from different distributions: uniform, Gaussian etc.
   - (b) Numerical integration.

Recommended books:

1. V. Rajaraman: Computer Oriented Numerical Methods

2. R. L. Burden and J. D. Faires : Numerical Methods.

CBCS curriculum for Semesterized Post-Graduate Course in Physics

SEMESTER-II

MURSHIDABAD UNIVERSITY

Course Code: PG-PHS-CC-201

Topic name: STATISTICAL MECHANICS

(50 marks=40 End SEM Exam+10 Internal) (4 credits)

(40 Lecture hours)

- **Objective of statistical mechanics:**

Microstates, microstates, random walk, phasespace and ensembles. Ergodic hypothesis, postulate of equal a-priori probability and equalityof ensemble average and time average. Boltzmann's postulate of entropy.Stirling's approximation and central limit theorem, Counting thenumber of microstates in phase space. Entropy of ideal gas:Sackur-Tetrode equation andGibbs' paradox. Liouville's Theorem. **[6 Lecture hours]**

- **Stationary ensembles:**

Micro canonical, canonical and grand canonical ensembles. Partition function formulation. Grand potential, fluctuation in energy and particle number. Equilibrium properties of ideal systems: ideal gas, Harmonic oscillators, rigid rotators. Para magnetism. **[5 Lecture hours]**

- Density Matrix; Quantum Liouville theorem; Density matrices for micro-canonical, canonical and grand-canonical systems; Simple examples of density matrices :one electron in amagnetic field, particle in a box; Identical particles (B-E and F-D distributions). [**5 Lecture hours]**

- **Phase Transition and Critical Phenomeona:**

Ising model---partition function for one dimensional case; Chemical equilibrium and Sahaionisation formula. Phase transitions---first order and continuous, critical exponents and scalingrelations. Calculation of exponents from Mean Field Theory and Landau's theory, uppercritical dimension.

[8 lecture hours]

- **Non-equilibrium Statistical Mechanics:**

Irreversible processes, Classical Linear Response Theory, Brownian Motion, Master Equation,Fokker-Planck Equation, Fluctuation-Dissipation Theorem.

[8 lecture hours]

- Fermi and Bose distributions; quantum gas in equilibrium; Quantum gases of elementary particles; number density and chemical potential; energy density, equation of state and different thermodynamic quantities; relativistic quantum gas; black body radiation and Planck's law; degenerate Bose gas; lattice specific heat and phonons; Bose condensation and super fluidity; quantum liquid with Bose-type spectrum example of liquid He; Landau criterion; degenerate Fermi gas; degeneracy pressure; specific heat of degenerate Fermi gas; Riemann's ζ(z) and integrals of quantum statistics : relativistic degenerate electron gas; high temperature dense matter; white dwarfs and neutron stars. **[8 Lecture hours]**

Recommended Books:

1. R. K. Pathria and P.D. Beale, Statistical Mechanics, Academic press, 3rd Ed.
2. K. Huang, Introduction to Statistical Mechanics, Taylor and Francis, 2nd Ed.
3. F. Mandl: Statistical Physics
4. F. Reif, Fundamentals of Statistical and Thermal Physics.MacGrowHill.
5. Landau
6. and Lifshitz: Statistical Mechanics – Pergamon
7. S. K. Ma, Modern Theory of Critical Phenomena, Westview Press, 1st Ed.

Course Code: PG-PHS-CC-202

Topic name: SOLID STATE PHYSICS

(50 marks=40 End SEM Exam+10 Internal) (4 credits)

(40 Lecture hours)

- **Structure of solids:**

Bravais lattice, primitive vectors, primitive unit cell, conventional unit cell, Wigner-Seitzcell; Symmetry operations and classification of 2- and 3-dimensional Bravais lattices; pointgroup and space group (information only); Common crystal structures: NaCl and CsCl structure, close-packed structure, Zinc blende and Wurtzite structure, tetrahedral and octahedral interstitial sites, Spinel structure; Intensity of scattered X-ray, Friedel's law, Anomalous scattering; Atomic and geometric structure factors; systematic absences; Reciprocal latticeand Brillouin zone; Ewald construction; Explanation of experimental methods on the basisof Ewald construction; Electron and neutron scattering by crystals (qualitative discussion); Surface crystallography; Graphene; Real space analysis HRTEM, STM, FIM. Non crystalline solids, Monatomic amorphous materials; Radial distribution function; Structure ofvitreous silica. **[9 lecture hours]**

- **Band theory of solids:**

Bloch equation; Empty lattice band; Number of states in a band; Effective mass of anelectron in a band: concept of holes; Classification of metal, semiconductor and insulator;Electronic band structures in solids - Nearly free electron bands; Tight binding method – applicationto a simple cubic lattice; Band structures in copper, GaAs and silicon; Topology ofFermi-surface; Quantization of orbits in a magnetic field, cyclotron resonance de Haas-van Alphen effect; Boltzmann transport equation - relaxation time approximation, Somerfieldtheory of electrical conductivity. **[7 lecture hours]**

- **Lattice dynamics and Specific heat:**

Classical theory of lattice vibration under harmonic approximation; Dispersion relations ofone dimension lattices: monatomic and diatomic cases, Characteristics of different modes,long wavelength limit, Optical properties of ionic crystal in the infrared region; Inelasticscattering of neutron by phonon; Lattice heat capacity, models of Debye and Einstein, comparisonwith electronic heat capacity; Anharmonic effects in crystals - thermal expansion.

[7 lecture hours]

- **Dielectric properties of solids:**

Electronic, ionic, and orientational polarization; static dielectric constant of gases and solids;Complex dielectric constant and dielectric losses, relaxation time, Debye equations; Casesof distribution of relaxation time, Cole-Cole distribution parameter, Dielectric modulus;Ferroelectricity, displacive phase transition, Landau Theory of Phase Transition. **[7 lecture hours]**

- **Magnetic properties of solids:**

Origin of magnetism; Diamagnetism: quantum theory of atomic diamagnetism; Landau diamagnetism(qualitative discussion); Paramagnetism: classical and quantum theory of para-magnetism; case of rare-earth and iron-group ions; quenching of orbital angular momentum;Van-Vleck paramagnetism and Pauli paramagnetism; Ferromagnetism: Curie-Weisslaw, temperature dependence of saturated magnetisation, Heisenberg's exchange interaction,Ferromagnetic domains - calculation of wall thickness and energy; Ferrimagnetism and antiferromagnetism. **[10 lecture hours]**

Recommended books:

1. N.W. Ashcroft and N.D. Mermin: Solid State Physics
2. J.R. Christman: Fundamentals of Solid State Physics
3. A.J. Dekker: Solid State Physics
4. C. Kittel: Introduction to Solid State Physics
5. H. Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiment
6. J.P. Srivastava: Elements of Solid State Physics
7. J.P. McKelvey: Solid State and Semiconductor Physics

Course Code: PG-PHS-CC-203

Topic name: NUCLEAR AND PARTICLE PHYSICS
(50 marks=40 End SEM Exam+10 Internal) (4 credits)
(40 Lecture hours)

- **Nuclear properties:**

(a) Basic nuclear properties: nuclear size, nuclear shape, nuclear radius and charge distribution, parity, symmetry and isospin of nuclei, muonic atoms and electron scattering, Rutherford scattering, nuclear form factor, mass and binding energy, angular momentum, electric quadrupole and magnetic dipole moments.

(b) Two-nucleon problem and nuclear forces: Bound-state problem – relative stability of neutron (n)-neutron, neutron-proton (p) and proton-proton systems, properties of the deuteron, Deuteron ground state, excited states, two-nucleon scattering, n-p scattering, partial wave analysis, phase-shift, scattering length, p-p scattering (qualitative discussion), exchange nature of nuclear forces, elementary discussion on Yukawa's theory.

(9 lecture hours)

- **Structure of complex nuclei and nuclear models:**

Qualitative discussion about ground state and stability of nuclei of small mass numbers, nuclear many-body theory and need for nuclear models, liquid drop model, Bethe-Weizacker mass formula; shell model – shell structure and magic numbers, effective single-particle potentials with spin-orbit interaction , success and failure of shell model in predicting ground state, spin, parity and electro-magnetic moments, anomalous magnetic moments of nucleons, collective model–evidence of collective motion, vibrational and rotational spectra, phonons. **(9 lecture hours)**

- **Beta and Gamma decay:**

Energetics and theory for allowed β decay, selection rules for Fermi and Gamow-Teller transitions, weak interaction and parity non-conservation, experimental verification of parity violation, gamma–decay and selection rules (derivation of transition probabilities not required). **(5 lecture hours)**

- **Nuclear reaction and fission:**

Types of reaction, quantum mechanical theory, Q values, scattering reaction and resonance, Breit-Wigner formula, compound nucleus formation and break up, optical model, nuclear fission and liquid drop model, Elementary ideas about astrophysical reactions, Nucleosynthesis and abundance of elements. **(7 lecture hours)**

- **Elementary particles:**

(i) Historical introduction-electron, photon, mesons, antiparticles, neutrinos, strange particles, eightfold way, the four forces- Strong, electromagnetic, weak and gravitational, strong interaction, symmetries and conservation laws, charge-conjugation, Parity and Time reversal, CPT theorem, Gell-Mann-Nishijima formula, intrinsic parity of pions, resonances, symmetry classification of elementary particles, quark hypothesis, charm, beauty and truth, gluons, quark-confinement, asymptotic freedom.

(ii) Particle dynamics: Hadrons, isospin and hyper charge, SU(3) algebra, quarks and gluon, Gellman-Okubo mass formula, electroweak theory-elementary ideas of electroweak unification, introduction to the standard model or Weinberg –Salam theory. **(10 lecture hours)**

Books Recommended:

1. E. G. Segre, *Nuclei and Particles: An Introduction to Nuclear and Subnuclear Physics*, W.A. Benjamin (1965)
2. R. R. Roy and B. P. Nigam, *Nuclear Physics: Theory and Experiment*, New Age Publishers (1996)
3. Preston and Bhaduri, *The structure of Nuclear Physics*, Avalon Publishing (1993)
4. S. N. Ghoshal , *Nuclear Physics*, S Chand; Second edition (1994)
5. D. J. Griffith, *Introduction to Elementary Particle Physics,* John Wiley & Sons, INC (1983)
6. K. S. Krane, *Introductory nuclear Physics*, John Wiley & Sons(1988)

7. W. L. Cottingham and D A Greenwood, *An Introduction to Nuclear Physics*, Cambridge University Press (2004)
8. Brian R Martin, *Nuclear and Particle Physics: An Introduction*, John Wiley & Sons (2011)
9. Gordon L Kane, *Modern Elementary Particle Physics*, Westview Press (1994).
10. W.E. Burcham and M. Jobes, Nuclear and particle Physics
11. M. A. Preston and R. K. Bhaduri, Structure of the Nucleus.
12. M. K. Pal, Nuclear structure.

Course Code: PG-PHS-CC-204

Topic name: ELECTRONICS
(50 marks=40 End SEM Exam+10 Internal) (4 credits)
(40 Lecture hours)

- **SEMICONDUCTOR DEVICES:**

(i) p-n junction physics- Fabrication steps; thermal equilibrium condition; depletion capacitance; current-voltage characteristics; charge storage and transient behavior; junction breakdown; heterojunction.
(ii) Characteristics of some semiconductor devices- BJT, JFET, MOS, LED, Solar cell, Tunnel diode, Gunn diode and IMPATT. (5 **lecture hours)**

- **ACTIVE CIRCUITS:**

(i) Transistor amplifiers- Basic design consideration; high frequency effects; video and pulse amplifier; resonance amplifier; feedback in amplifiers.
(ii) Harmonic self-oscillators, Steady state operation of self-oscillator; nonlinear equation of self-oscillator; examples. (**5 lecture hours)**

- **POWER CIRCUIT:**

Series-fed class A amplifier; Harmonic distortion; Higher harmonic generation;Transformer- coupled amplifier; Class B amplifier; Crossover distortion; Class AB amplifier; Class C amplifier. (**5 lecture hours)**

- **FILTERS:**

Constant k and m derived low and high pass, bandpass and band eliminator filters; propagation constants; Butterworth filters, Delay equalizer.
(**5 lecture hours)**

- **DIGITAL CIRCUITS:**

Logic functions; logic simplification using Karnaughmaps, SOP and POS design of logic circuits; MUX as universal building block; Shift register; Counter; D/A converter; Summing R- 2R ladder type; A/D convertor.
(**5 lecture hours)**

- **OP-AMP BASED CIRCUITS:**

Characteristics of ideal and practical op-amp; Nonlinear amplifiers using op-amp; log amplifier; antilog amplifier; regenerative comparator; op-amp based oscillators: sinusoidal and relaxation oscillator; **(5 lecture hours)**

- **Communication:**

Amplitude modulation and detection: side band, power relation, modulation index, amplitude modulated waves, envelope, average detection.

(5 lecture hours)

- **Frequency modulation and detection:**

Concepts of frequency and phase modulation, frequency spectrum, bandwidth, reactance tube and p-n junction method of generation FM waves; Armstrong system; demodulation by staggered, tuned a d Foster Seely discriminatory circuit. **(5 lecture hours)**

Books Recommended:

1. Millman and Halkias: Integrated Electronics-McGraw Hill Kogakusha
2. S.M.Zee Physics of semiconductor devices.
3. Chattopadhyay and Rakshit, Electronics Circuit Analysis.
4. D. P. Leach, A. P. Malvino, G. Saha, Digital Principles and Applications, Tata MacGraw Hill.
5. R. P. Jain, Modern digital electronics, Tata MacGraw Hill.
6. J. D. Ryder, Electronics fundamental and application, PHI.
7. Gaykwad, Operational Amplifier.
8. Roddy and Coolen,Electronic Communication systems, PHI.
9. Tobey, Graeme and Huarlseman : Operational amplifiers-McGraw Hill Kigalushs
10. Vander Ziel ,Solid State Physical Electronics, Prentice Hall India
11. Taub Schilling, Digital Integrated Electronics, McGraw Hill Kogakusha
12. Kennedy, Electronic Communication system, Tata McGraw-Hill, New Delhi, 1991
13. Carlson,Communication system ,Tata McGraw-Hill, New Delhi, 1991
14. Milman, Microelectronics, Tata McGraw-Hill, New Delhi, 1991

15. Malvino and LeachDigital Principle and applications Tata McGraw-Hill, New
16. Malvino, Digital Computer Electronics ,Tata McGraw-Hill, New Delhi, 1991
17. Streetman, Solid State Electronic Devices,Prentice Hall
18. B.C.Sarkat and S.Sarkar, Analog Electronics, DamodarPrakashani
19. D.RoyChowdhuri and Jain, Analog Integrated Circuit ,New Age Publishers
20. B.C. Sarkar and S.Sarkar, Digital Electronics

Paper code: PG-PHS-CC-205(P)

Topic name: GENERAL PHYSICS PRACTICAL-II

(50 marks) (4 credits)

1. Determination of mean wavelength and separation of wavelengths of sodium light by Fabry Perot interferometer
2. a) Calibration of a Michelson interferometer using Na-D lines as standard.
   b) Measurement of d between Na-D lines.
3. Study of dispersion relation in a periodic electrical circuit: an analog of monatomic and diatomic lattice vibrations.
4. Determination of (i) Rydberg constant, (ii) ionisation potential and (iii) quantum defect of an alkali atom.
5. Study of Zeeman effect : determination of e/m, Lande g-factor of electrons.
6. Determination of Bohr magneton of an electron
7. Determination of wavelength of sodium light using Lloyd's mirror.
8. Energy band gap of a semiconductor by four probe method/studying temperature variation of resistance.
9. Energy band gap of semiconductor by studying the luminescence spectra.
10. Calibration of audio oscillator by the method of propagation of sound wave and formation of Lissajous' figures.
11. Verification of Bohr's atomic theory by Franck Hertz Experiment.
12. Characteristics and Study of CE amplifier circuit (AC mode) with and without feedback.
13. To Study the amplitude modulation technique and determination of the modulation index.
14. To study the characteristics of an (1) Active filter, (2) Bandpass filter and (3) All Pass Filter using Op-Amp.
15. To study the characteristics of an Op-amp based nonlinear amplifier.
16. To study the input and output voltage characteristics of Schmitt trigger circuit.

17. Study of characteristics of FET and MOSFET and use of these as source followers.
18. To test the performance of digital gates using ICs.
19. Determination of Hall coefficient and carrier concentration.
20. Transistor series voltage regulation circuit.

CBCS curriculum for Semesterized Post-Graduate Course in Physics

SEMESTER-III

MURSHIDABAD UNIVERSITY

Course Code: PG-PHS-CC-301

Topic name: ATOMIC, MOLECULAR AND LASER PHYSICS

(50 marks=40 End SEM Exam+10 Internal) (4 credits)
(40 Lecture hours)

- **Atomic Physics:**

Fine structure of hydrogenic atoms, Mass correction, spin-orbit term, Darwin term. Intensity of fine structure lines. Effect of magnetic and electric fields: Zeeman, Paschen-Bach and Stark effects. The ground state of two-electron atoms – perturbation theory and variational methods. Many-electron atoms – Central Field Approximation-LS and jj coupling schemes, Lande interval rule. The Hartrec-Fock equations. The spectra of alkalis using quantum defect theory. Selection rules for electric and magnetic multipole radiation. Auger process. **(10 lecture hours)**

- **Molecular Structure:**

Born-Oppenheimer approximation for diatomic molecules, rotation, vibration and electronic structure of diatomic molecules. Spectroscopic terms. Centrifugal distortion. Electronic structure-Molecular symmetry and the states. Molecular orbital and valence bond methods for H_2^+ and H_2. Morse potential. Basic concepts of correlation diagrams for heteronuclear molecules.

(10 Lecture hours)

- **Molecular Spectra:**

Rotational spectra of diatomic molecules-rigid and non-rigid rotors, isotope effect, Vibrational spectra of diatomic molecules- harmonic and anharmonic vibrators, Intensity of spectral lines, dissociation energy, vibration-rotation spectra, Electronic spectra of diatomic molecules- vibrational structure of electronic transitions (coarse structure)-progressions and sequences. Rotational structure of electronic bands (Fine structure)-P,Q,R branches. Fortrat diagram. Intensities in electronic bands-The Franck- Condon principle.The electron spin and Hund's cases. Raman Effect. Electron Spin Resonance. Nuclear Magnetic Resonance. **(10 Lecture hours)**

Lasers: Life time of atomic and molecular states. Multilevel rate equations and saturation. Coherence and profile of spectral lines. Rabi frequency. Laser pumping and population inversion. He-Ne Laser, Solid State laser, Free-electron laser. Non-linear phenomenon. Harmonic generation. Liquid and gas lasers, semiconductor lasers. **(10 Lecture hours)**

Reference books:

1. Physics of Atoms and Molecules by B. H. Bransden and C. J. Joachain (2nd Ed., Pearson Education, 2003)
2. Atomic Spectra and Atomic Structure by G. Herzberg (Dover Publications, 2003)
3. Molecular Spectra and Molecular Structure by G. Herzberg (Van Nostrand, 1950)
4. Atoms, Molecules and Photons by W. Demtroder (Springer, 2006)
5. Fundamentals of Molecular Spectroscopy by C. N. Banwell (McGraw Hill, 1983)
6. Basic atomic & Molecular Spectroscopy by J. M. Hollas (Royal Society of Chemistry, 2002)
7. Principles of Lasers by O. Svelto (5th Ed., Springer, 2010)
8. Laser Spectroscopy by W. Demtroder (3rd Ed., Springer, 2003)
9. Molecular Quantum Mechanics by P Atkins & R. Friedman (Oxford Univ. Press, 2005)

10. Quantum Chemistry by I. N. Levine.

Paper code: PG-PHS-CC-302

Topic name: QUANTUM MECHANICS-II

(50 marks=40 End SEM Exam+10 Internal) (4 credits)
(40 Lecture hours)

- **Approximation methods:**

Time independent perturbation theory for non – degenerate (correction of energy eigenvalues up to second order and wave functions up to first order) and degenerate (only first order correction) states. Applications: Anharmonic oscillator, Stark effect in hydrogen atom. Time dependent perturbation theory; Constant and harmonic perturbations; Fermi's golden rule; Sudden and adiabatic approximations; WKB approximation; Quantization rule, Tunneling through a barrier, Qualitative discussion of α-decay.

[**12 Lecture hours**]

- **Scattering theory:**

Laboratory and centre of mass frames, Differential and total scattering cross-sections, Scattering amplitude; Scattering by spherically symmetric potential; Partial wave analysis and phase shifts; Relation between sign of phase shift and attractive or repulsive nature of the potential; Scattering by a rigid sphere; Born approximation, First Born approximation, Validity of the first Born approximation; Scattering from Coulomb potential. [**12 Lecture hours**]

- **Symmetries:**

Conservation laws associated with symmetries; Continuous symmetries – space and time translations, rotations; Discrete symmetries – reflection, inversion and parity, intrinsic parity, time reversal; Kramer's degeneracy.

[**6 Lecture hours**]

- **Identical particles:**

Meaning of identity and consequences; Symmetric and anti-symmetric wave functions; Slater determinant; Symmetric and anti-symmetric spin wave functions of two identical particles. [**3 Lecture hours**]

- **Relativistic quantum mechanics:**

Klein-Gordon equation, interpretation of negative energy-momentum solutions of free particle and concept of antiparticles; Dirac equation, Covariant form, Adjoint equation; Non-relativistic correspondence; Spin, helicity and magnetic moment of the Dirac particle; Gamma matrices, their different representations and properties; Charge conjugation.

[**7 Lecture hours**]

Reference Books:

1. S. Gasiorowicz : Quantum Physics
2. J. J. Sakurai : Modern Quantum Mechanics & Advanced Quantum Mechanics
3. E. Merzbacker ; Quantum Mechanics
4. B. H. Bransden and C. J. Joachain : Introduction to Quantum Mechanics
5. David Griffiths : Introduction to Quantum Mechanics
6. P. M. Mathews and K. Venkatesan : A Text Book of Quantum Mechanics
7. J. D. Bjorken and S. D. Drell : Relativistic Quantum Mechanics
8. W. Greiner : Relativistic Quantum Mechanics
9. A. Lahiri and P. B. Pal : A First Book of Quantum Field Theory
10. A. F. J. Levi : Applied Quantum Mechanics

Course Code: PG-PHS-DSE-303(A)

Topic name: DISCIPLINE SPECIFIC ELECTIVE-I

(ELECTRONICS)

(50 marks=40 End SEM Exam+10 Internal) (4 credits)

(40 Lecture hours)

- **INTEGRATED CIRCUIT:**

Fabrication technique of IC components and devices LSI,VLSI.

[**5 lecture hours]**

- **EPITAXIAL GROWTH OF SEMICONDUCTOR:**

Epitaxial growth of Si-layer by vapour phase reduction of SiCl3 , kinetics of growth, surface reduction control, Molecular beam epitaxy. [**5 lecture hours]**

- **SOLID STATE DEVICES:**

(1) Tunnel Diode: Effect of high doping, degenerate semiconductors, energy band diagram of a tunnel diode in equilibrium and different biasing conditions, tunnelling current , excess current and thermal current.

(2) SOLAR CELL AND LED: Principle and operation of a p-n junction solar cell, energy-band diagram, I-V characteristics ,limitation of solar cell , photodiode,direct and indirect band gap semiconductor, construction and materials used for fabrication of LED , principle of operation of LED.

(3) MIS DIODE: Energy band diagram of ideal metal-insulator semiconductor diodes in equilibrium and under different applied voltages.

(4) METAL-SEMICONDUCTOR CONTACT: Energy-band diagram of metal semiconductor contact under different biasing conditions, Schottkey effect, current-voltage relationship.

(5) IMPATT DIODE: Principle of operation and characteristic curve of a Gunn diode. (6) GUNN DIODE: Principle of operation and characteristic curve of a Gunn diode Simplified band diagram of GaAs. [**18 lecture hours]**

- **OPTOELECTRONICS:**

Classification and fabrication principle of optical fibers , step and graded index fibers, wave propagation in optical fiber media, losses in fiber, optical fiber source and detector, fiber characteristics, basic principle of optical fiber communication, digital optical fiber communication systems.

[**6 lecture hours]**

- **QUANTUM ELECTRONICS:**

Spontaneous and stimulated emission of radiation, Einstein's coefficients, Laser rate equation and lasing condition, 3 level laser system , He-Ne laser, CO laser, semiconductor laser, maser technique and principle. [**6 lecture hours]**

Recommended Books:

1. Physics of semiconductor devices: Wiley Inter Science –Sze
2. Solid State Electronic Devices:Prentice Hall India: Streetman
3. Semiconductots: Cambridge: Smith
4. Physics and Technology of semiconductor devices: John Wiley: Grove
5. Laser Physic---Tata McGraw Hill: Ghatak
6. Optical Fiber Communication:Tata McGraw Hill: Keiser
7. Optical Fiber System Technology and design: Tata McGraw Hill:Kao
8. Optical Communication Systems: Prentice Hall India: Gower.

Course Code: PG-PHS-DSE-303(B)

Topic name: DISCIPLINE SPECIFIC ELECTIVE-I

(SOLID STATE PHYSICS)

(50 marks=40 End SEM Exam+10 Internal) (4 credits)

(40 Lecture hours)

- **Imperfections in solids:**

Frenkel and Schottky defects, defects by non stoichiometry; electrical conductivity of ionic crystals; classifications of dislocations; role of dislocations in plastic deformation and crystalgrowth; Colour centers and photoconductivity; Luminescence and phosphors; Alloys, Hume-Rothery rules; electron compounds; Bragg - Williams theory, order-disorder phenomena,superstructure lines; Extra specific heat in alloys.

[10 lecture hours]

- **Superconductivity:**

Phenomenological description of superconductivity - occurrence of superconductivity, destructionof superconductivity by magnetic field, Meissner effect; Type-I and type-II superconductors;Heat capacity, energy gap and isotope effect; Outlines of the BCS theory; Giavertunnelling; Flux quantisation; a.c. and d.c. Josephson effect; Vortex state (qualitative discussions); High T_C superconductors (information only). Bogoliubov transformation– notionof quasiparticles; Ginzburg-Landau theory and London equation; Meissner effect; Type II superconductors– characteristic length; Josephson Effect; “Novel High Temperature" superconductors.

[18 lecture hours]

- **Superfluidity:**

(i) Superfluid Helium 4 : Basic Phenomenology; Transition and Bose-Einstein condensation; Two-fluid model; Vortices in a rotating superfluid,Roton spectrum and specific heat calculation, critical velocity. (ii) Superfluid Helium3: Basic Phenomenology; Pair condensationin a Fermi liquid, Superfluid phases of Helium-3. [**6 lecture hours]**

- **Magnetic resonances:**

Nuclear magnetic resonances, paramagnetic resonance, Bloch equation, longitudinal andtransverse relaxation time; spin echo; motional narrowing in line width; absorption and ispersion; Hyperfine field; Electron-spin resonance.

[6 lecture hours]

Recommended books:

1. N.W. Ashcroft and N.D. Mermin: Solid State Physics

2. J.R. Christman: Fundamentals of Solid State Physics

3. A.J. Dekker: Solid State Physics

4. C. Kittel: Introduction to Solid State Physics

5. H. Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiment

6. J.P. Srivastava: Elements of Solid State Physics

7. J.P. McKelvey: Solid State and Semiconductor Physics

Course Code: PG-PHS-DSE-303(C)

Topic name: DISCIPLINE SPECIFIC ELECTIVE-I

(NUCLEAR AND PARTICLE PHYSICS)

(50 marks=40 End SEM Exam+10 Internal) (4 credits)

(40 Lecture hours)

- Importance of electron scattering in probing the structures of nucleon and nucleus, elastic electron scattering on the proton, form factors and anomalous magnetic moment of the proton, electric and magnetic form factors in the Breit frame of reference; **(8 lecture hours)**
- Nucleon-nucleon force-charge-symmetry and charge independence, concept of isospin. Probable form of nucleon-nucleon potential from general symmetries, exchange forces, meson theory of nucleon forces, phenomenological potentials-effective of nucleon-nucleon interaction in nuclei. **(8 lecture hours)**
- Shell model-nucleons in a harmonic oscillator potential, radial density distribution, estimate of oscillator frequency, spin-orbit potential, magic numbers, spin, magnetic and electric quadrupole moment of nuclei, residual interaction, single particle model, odd-odd nuclei, Nordheim's rules, many particle shell model. **(10 lecture hours)**
- Collective model-Collective Hamiltonian, vibrational spectra, ellipsoidally deformed nuclei, total deformation parameter and non- axiality parameter, Moment of inertia –rigid and irrotational values. High Spin states,qualitative explanation, coriolis anti-pairing, cranking formula for the moment of inertia of deformable nucleus. **(8 lecture hours)**
- Particle accelerators: Pelletron, tandem principle, Synchrotron and Synchrosyclotron, colliding beams, threshold energy for particle production. **(6 lecture hours)**

Books Recommended:

11. E. G. Segre, *Nuclei and Particles: An Introduction to Nuclear and Subnuclear Physics*, W.A. Benjamin (1965)
12. R. R. Roy and B. P. Nigam, *Nuclear Physics: Theory and Experiment*, New Age Publishers (1996)
13. Preston and Bhaduri, *The structure of Nuclear Physics*, Avalon Publishing (1993)
14. S. N. Ghoshal , *Nuclear Physics*, S Chand; Second edition (1994)
15. D. J. Griffith, *Introduction to Elementary Particle Physics,* John Wiley & Sons, INC (1983)
16. K. S. Krane, *Introductory nuclear Physics*, John Wiley & Sons(1988)
17. W. L. Cottingham and D A Greenwood, *An Introduction to Nuclear Physics*, Cambridge University Press (2004)
18. Brian R Martin, *Nuclear and Particle Physics: An Introduction*, John Wiley & Sons (2011)
19. Gordon L Kane, *Modern Elementary Particle Physics*, Westview Press (1994).
20. W.E. Burcham and M. Jobes, Nuclear and particle Physics

11. M. A. Preston and R. K. Bhaduri, Structure of the Nucleus.
12. M. K. Pal, Nuclear structure.
13. S. N. Mukherjee Elements of Nuclear Theory: (CBS Publisher)
14. H. Enge, Introduction to Nuclear Physics.
15. John M Blatt and Victor F Wiesskopf, Theoretical Nuclear Physics.
16. M. A. Preston and R K Bhaduri, Structure of the Nucleus.
17. Mark Thomson, Modern Particle Physics - (Cambridge University Press)
18. D.H. Perkins, Introduction to High Energy Physics - (Addison Wesley)
19. W.E. Burcham and M. Jobes, Nuclear and Particle Physics - (Addison Wesley).

Course Code: PG-PHS-GE-322

Topic name: APPLIED PHYSICS (GENERAL ELECTIVE)

(50 marks=40 End SEM Exam+10 Internal) (4 credits)
(40 Lecture hours)

Module-I

- **Basic Physics**:

Newtonian mechanics: Vectors; Newton's laws of motion; Force and acceleration; Work, Energy, Power; Newton's laws of Gravitation; Projectiles; Friction; Circular motion; Moment of Inertia. **[5 lecture hours]**

- **Ray optics**:

Reflection and Refraction at a plane boundary; Refractive index; Snell's law; Fermat's principle; Image formation by reflection at a spherical boundary; Concave and Convex mirrors; Lenses. **[5 lecture hours]**

- **Wave Optics**:

Interference, Diffraction, polarization. **[5 lecture hours]**

- **Elements of electricity and magnetism**:

Electric field and potential, Gauss law, Biot-Savart law, Ampere Circuital law, Maxwell's equation, Electromagnetic wave Modern physics and relativity: Structure of atoms and nucleus, Radioactivity, Fission, Fusion, Superconductivity, Special theory of relativity. **[5 lecture hours]**

Module-II

- **Applied Quantum Mechanics:**

Basics: Schrödinger equation, Measurements, Expectation values, Stationary states, Approximation methods: Variational principle, Time independent and Time dependent

perturbation theory; WKB approximation. **[10 lecture hours]**

Some elementary examples:

(a) Free electrons in one dimension,

π - states in benzene; free electrons in three dimensions.

(b) Quantum slabs, wires and dots; quantum wells.

(c) The hydrogen atom problem. **[10 lecture hours]**

Course Code: PG-PHS-CC-304(P)

Topic name: ADVANCE PHYSICS PRACTICAL-I

(50 marks) (4 credits)

(Group- A)**

1. Magnetic parameters of a magnetic material by hysteresis loop tracer.
2. Study of temperature variation of refractive index of a liquid using hollow prism and laser source.
3. Study of gamma absorption in Aluminium and Lead using a GM tube and determination of the mass absorption coefficient.
4. Study of beta absorption in Aluminium using a GM tube and determination of range and energy of beta particles.
5. Study of the molecular spectra of I2 in absorption and determination of the dissociation energy.
6. Dielectric constant measurement as a function of temperature and frequency.
7. To study the characteristics of an Op-amp based non-linear Amplifier.
8. Determination of Lande splitting factor by ESR Spectrometer.
9. To Study the amplitude modulation technique and determination of the modulation index.
10. Studies on LED nad LED based practical.
11. Study of the current mirror biasing and VBE multiplier based voltage reference.
12. To study the characteristics of an Op-amp based nonlinear amplifier.

(Group- B)**

1. Determination of particle size of an unknown powder specimen using Scherrer equation from supplied XRD pattern.
2. Intensity dependent nonlinear susceptibility of nonlinear liquid by Z-scan technique.
3. Phase identification of an unknown sample from its X-ray diffraction pattern.
4. Study of photo-conductivity of a semiconductor material.
5. Study of characteristics of FET and MOSFET and use of these as source followers.
6. Study of characterization of antenna.
7. Programming with microprocessors.
8. Unijunction transistors, characteristics and use as saw-tooth generator.
9. Studies of nonlinear electronic circuits and design of chaotic electronic oscillator.
10. Study of Gaussian and Poisson distributions and error propagation using radioactive source and GM counter.
11. Study of the molecular spectra of I2 in absorption and determination of the dissociation energy.
12. Identification of liquid, solid or powder samples using Laser Raman Spectrometer.
13. Study of NMR.

**All the Students will be divided into two groups i.e. Group-A and Group-B and that will be decided by the Department.

CBCS curriculum for Semesterized Post-Graduate Course in Physics

SEMESTER-IV

MURSHIDABAD UNIVERSITY

Course Code: PG-PHS-DSE-401(A)

Topic name: DISCIPLINE SPECIFIC ELECTIVE-II (ELECTRONICS)

(50 marks=40 End SEM Exam+10 Internal) (4 credits)

(40 Lecture hours)

- **COMMUNICATION FUNDAMENTALS:**

Antenna: Basic considerations, antenna parameters, current distributions, halfwave dipole, longer antenna, image antenna, microwave antenna and other directional antenna. **[8 lecture hours]**

Propagation of radiowaves: Ground and surface wave propagation, ionosphere, virtual heights and critical frequencies of layers, propagation of radio waves through ionosphere, skip distance and MUF ,single hop and multihop transmission, Chapmann's theory, influence of earth's magnetic field, Appleton Hartree formula. **[8 lecture hours]**

- **SATELLITE COMMUNICATION:**

Principle of satellite communication, satellite frequency , allocation and band spectrum, communication satellite link design, satellite orbit and inclination, satellite applications, ideas of global communication network.

[8 lecture hours]

- **MEMORIES:**

Sequential and random access memories; RAM bipolar and MOS static and dynamic memories; Programmable memories PROM, EPROM, EEPROM.

[6 lecture hours]

- **MICROPROCESSOR AND MICROCONTROLLER:**

Basic idea of a microprocessor, 8085 architecture, registers , flags, instruction set, concept of assembly language programming, machine cycle, timing diagram, I/O ports, 8086 P fundamental, idea of recent advances of microprocessors, basic concepts of microcontroller 8051, architecture and programming model. **[10 lecture hours]**

Recommended Books:

1. Radiation and radiating systems: Prentice Hall India: Jordan and Balmain
2. Principles of communication systems- Tata McGraw Hill: Taub and Schilling
3. Communication System: Tata McGraw Hill: Carlson
4. Electronic and radio engineering: McGraw Hill: Terman
5. Antenn: McGraw Hill: Kraus
6. Microprocessor Architecture, programming and applications with 8085: Gaonkar
7. Digital computer electronics: Tata McGraw Hill : Malvino
8. Microprocessor and interfacing: Tata McGraw Hill: D.V Hall

Course Code: PG-PHS-DSE-401(B)

Topic name: DISCIPLINE SPECIFIC ELECTIVE-II

(SOLID STATE PHYSICS)

(50 marks=40 End SEM Exam+10 Internal) (4 credits)

(40 Lecture hours)

- **Fundamentals of many-electron system: Hartree-Fock theory:**

The basic Hamiltonian in a solid: electronic and ionic parts, the adiabatic approximation;Single-particle approximation of the many-electron system | single product and determinantalwave functions, matrix elements of one and two-particle operators; The Hartree-Fock(H-F) theory: the H-F equation, exchange interaction and exchange hole, Koopman's theorem;The occupation number representation: the many electron Hamiltonian in occupationnumber representation; the H-F ground state energy. **[10 lecture hours]**

- **The interacting free-electron gas: Quasi electrons and Plasmon:**

The H-F approximation of the free electron gas: exchange hole, single-particle energy levels,the ground state energy; Perturbation: theoretical calculation of the ground state energy;Correlation energy – difficultywith the second-order perturbation theoretic calculation,Wigner's result at high density, low-density limit and Wigner interpolation formula; Cohesiveenergy in metals; Screening and Plasmons; Experimental observation of plasmons. **[9 lecture hours]**

- **Spin-spin interaction: Magnons:**

Absence of magnetism in classical statistics; Origin of the exchange interaction; Direct exchange,super exchange, indirect exchange and itinerant exchange; Spin-waves in ferromagnetsand antiferromagnets (semi classical and quantum treatment using Holstein Primakoff transformation), spontaneous symmetry breaking in magnetic systems with continuous symmetry, thermodynamics of magnons, mean field theory and critical behaviour for large Smodels. **[8 lecture hours]**

- **Disordered systems:**

Disorder in condensed matter – substitutionalpositional and topographical disorder; Shortand Long – rangeorder; Atomic correlation function and structural descriptions of glasses andliquids; Anderson model; mobility edge; Minimum Metallic Conductivity, Qualitative applicationof the idea to amorphous semiconductors and hopping conduction. Percolationphenomena and the associated phase transition properties. **[8 lecture hours]**

- **Selected topics:**

Mott–transition, Stoner's criterion for metallic ferromagnet; Elementary introduction to Hubbard Model, Kondo effect. **[5 lecture hours]**

` Recommended books:

1. D. Pines: Elementary Excitations in Solids
2. S. Raimes: Many Electron Theory
3. O. Madelung: Introduction to Solid State Theory
4. N.H. March and M. Parrinello: Collective Effects in Solids and Liquids
5. H. Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiments
6. J.M. Ziman: Principles of the Theory of Solids
7. C. Kittel: Quantum Theory of Solids.

Course Code: PG-PHS-DSE-401(C)

Topic name: DISCIPLINE SPECIFIC ELECTIVE-II

(NUCLEAR AND PARTICLE PHYSICS)

(50 marks=40 End SEM Exam+10 Internal) (4 credits)

(40 Lecture hours)

- Two-nucleon scattering-partial wave analysis, effective range theory, coherent scattering, spin-flip and polarization, comparison of n-n and p-p scattering. **(8 lecture hours)**
- Nuclear reactions: Different kinds of nuclear-reactions, Direct reactions: Kinematics and theory of stripping, pick up, transfer reactions and reverse reactions; Reciprocity theorem; reaction and scattering cross sections, compound nuclear reactions, resonance reactions, experimental verification of Bohr's independence-hypothesis, Breit-Weigner formula, experimental determination of resonance widths and shapes, statistical theory, optical model, spectroscopic factors. Heavy-ion induced nuclear reaction and various phenomena. **(10 lecture hours)**
- Heavy ion reactions-salient features at low, intermediate and high energies, classical dynamical model, heavy ion fusion, fusion excitation function, deep inelastic collision. **(10 lecture hours)**
- **Experimental Techniques:**
  (a) Radiation detectors: general properties, modes of operation. Pulse height spectra, energy resolution, detector efficiency, peak-to-total ratio. X-ray, gamma-ray and charged particle spectrometers. Compton-suppressed germanium detectors, various channel selection devices, multi-detector array.
  (b) Nuclear Electronics: Pre-amplifier, Amplifier, Discriminators, Time to amplitude converter, Data acquisition systems.
  (c) Energy, timing and position sensitive spectroscopy. Measurement of level spin, linear polarization and lifetime. **(12 lecture hours)**

Books Recommended:

1. L.R.B Elton, Nuclear Physics.
2. Blatt and Weisskopf, Nuclear reactions.
3. Roy and Nigam, Nuclear Theory.
4. B. Cohen, Nuclear Physics.
5. Preston and Bhaduri, Nuclear Physics.
6. Bohr and Mottelson, Nuclear structure.
7. M. K. Pal, Nuclear structure.
8. Leo, Techniques in experimental nuclear physics.
9. G. F. Knoll, Techniques in experimental nuclear physics.
10. S. S. Kapur, Techniques in experimental nuclear physics.
11. C.A. Bertulani and D. Danielewicz, Introduction to Nuclear Reactions, (CRC Press)
12. R. Singh and S.N. Mukherjee, Nuclear Reactions (New Age International Pvt. Ltd.)
13. S.N. Mukherjee, Elements of Nuclear Theory - (CBS.)
14. K.M. Varier, Nuclear radiation detection, Measurement and Analysis - (Narosa).
15. W.R. Leo, Techniques for Nuclear and Particle Physics Experiments - (Springer)
16. G.F. Knoll, Radiation detection and Measurement - (Wiley)
17. R. R. Roy and B. P. Nigam, *Nuclear Physics: Theory and Experiment*, New Age Publishers (1996)
18. Preston and Bhaduri, *The structure of Nuclear Physics*, Avalon Publishing (1993)
19. S. N. Ghoshal , *Nuclear Physics*, S Chand; Second edition (1994)

Course Code: PG-PHS-CC-402

Topic name: APPLIED PHYSICS

(50 marks=40 End SEM Exam+10 Internal) (4 credits)
(40 Lecture hours)

Module - I

- **Data and error analysis**:

The presentation of physical quantities with their inaccuracies (measuring errors and uncertainties), Classification and propagation of errors.
[4 lecture hours]

- **Probability distributions:**

Binomial distribution; Poisson distribution; Gaussian or Normal distribution; Lorentziandistribution; the central limit theorem. **[4 lecture hours]**

- **Processing of experimental data:**

Distribution function of a data series; the average and The mean squared deviation of a data series; estimates for mean and variance;χ^2 Test of a distribution; handling data with unequal weights. **[4 lecture hours]**

- **Fitting functions to data:**

Dependent and independent variables, method of least squares, fitting to a polynomial, minimizing χ^2 for Goodness of Fit, Linear-Correlation Coefficient.
[4 lecture hours]

- **Numerical Methods:** Polynomial Interpolation, Numerical Differentiation and Integration, Roots of Nonlinear Equations. **[4 lecture hours]**

Module – II

- **Analytical techniques and their applications:**

Characterization Techniques in Materials Science: Optical microscopy, electron microscopy, Spectrophotometry, Raman spectroscopy,Atomic force microscopy (AFM), X ray Diffraction. NuclearMagnetic Resonance.
[7 lecture hours]

- **Atomic and Nuclear analytical methods:**

X-ray Fluorescence (XRF) and Particle -Induced X-ray Emission (PIXE), Rutherford Backscattering Spectroscopy, Neutron Activation Analysis, Accelerator Mass Spectrometry. **[7 lecture hours]**

- **Biological effects of radiation:**

Physical and chemical damage; dose, dose rate; Damageof tissue levels, Radiation shielding and its safety, Nuclear Medicine; Radiation.

[6 lecture hours]

Course Code: PG-PHS-CC-403(P)

Topic name: ADVANCE PHYSICS PRACTICAL-II

(50 marks) (4 credits)

(Group- A)***

1. Magnetic parameters of a magnetic material by hysteresis loop tracer.
2. Study of temperature variation of refractive index of a liquid using hollow prism and laser source.
3. Study of gamma absorption in Aluminium and Lead using a GM tube and determination of the mass absorption coefficient.
4. Study of beta absorption in Aluminium using a GM tube and determination of range and energy of beta particles.
5. Study of the molecular spectra of I2 in absorption and determination of the dissociation energy.
6. Dielectric constant measurement as a function of temperature and frequency.
7. To study the characteristics of an Op-amp based non-linear Amplifier.
8. Determination of Lande splitting factor by ESR Spectrometer.
9. To Study the amplitude modulation technique and determination of the modulation index.
10. Studies on LED nad LED based practical.
11. Study of the current mirror biasing and VBE multiplier based voltage reference.
12. To study the characteristics of an Op-amp based nonlinear amplifier.

(Group- B)***

1. Determination of particle size of an unknown powder specimen using Scherrer equation from supplied XRD pattern.
2. Intensity dependent nonlinear susceptibility of nonlinear liquid by Z-scan technique.
3. Phase identification of an unknown sample from its X-ray diffraction pattern.
4. Study of photo-conductivity of a semiconductor material.
5. Study of characteristics of FET and MOSFET and use of these as source followers.
6. Study of characterization of antenna.
7. Programming with microprocessors.
8. Unijunction transistors, characteristics and use as saw-tooth generator.
9. Studies of nonlinear electronic circuits and design of chaotic electronic oscillator.
10. Study of Gaussian and Poisson distributions and error propagation using radioactive source and GM counter.
11. Study of the molecular spectra of I2 in absorption and determination of the dissociation energy.
12. Identification of liquid, solid or powder samples using Laser Raman Spectrometer.
13. Study of NMR.

***All the Students will be divided into two groups i.e. Group-A and Group-B. Those students who have done Group-A experiments in Semester-III will have to opt Group-B experiments in Semester-IV and vice-versa.

Course Code: PG-PHS-CC-404 (P)

Topic name: PROJECT

(50 marks=40 End SEM Exam+10 Internal) (4 credits)

In 4th Semester there is a Project work for each student and they have to do it in his home university or in any recognized Institution/College or University.

F.M: 40 [Content of dissertation:15, Final presentation:15, Viva-Voce:10]

Internal assessment of 10 marks will be carried out by the respective supervisors.

Course Code: PG-PHS-CC-405(P)

Topic name: GRAND VIVA

(50 marks) (4 credits)

At the last of the 4th Semester a Grand viva will be taken on whole PG syllabus.