

Structure for M.Sc. Syllabus

Effective from June 2017

SEMESTER- II

M.Sc. (PHYSICS)

Sr. No.	Course Code	Course Title	L	T	Cr.
1	PH-421	Quantum Mechanics -I	4	1	4
2	PH-422	Solid State Physics	4	1	4
3	PH-423	Classical Electrodynamics	4	1	4
4	PH-424	Numerical Analysis and Computer Programming	4	1	4
5	PH-425	Practical	9	1	8
			25	05	24

Faculty Code: **Science**Subject Code: **PH**Level Code: **03**Name of Program: **M.Sc.**Subject: **PHYSICS**External Examination Time Duration: **03 Hours**

Name of Exam	Semester	PAPER No.	Course Group	Credit	Internal Marks	External Marks	Total Marks
M.Sc.	2	PH-421	Core	04	30	70	100
		PH-422	Core	04	30	70	100
		PH-423	Core	04	30	70	100
		PH-424	Core	04	30	70	100
		PH-425	Practical	08	60	140	200
		TOTAL		24	180	420	600



**DEPARTMENT OF PHYSICS,
VEER NARMAD SOUTH GUJARAT UNIVERSITY,
SURAT -395007**

**M.Sc. Syllabus 2017
M. Sc. (Physics): Semester-II**

PH-421: QUANTUM MECHANICS - I

Unit 1 **Origin of Quantum Physics**

Particle aspect of radiation, wave aspect of particles, wave-particle duality, wave packets, wave packets and uncertainty relations, motion of wave packets.

Mathematical Tools of Quantum Mechanics:

The Hilbert space and Wave functions, Dimension and basis of vector space, Dirac notation, Operators, Hermitian adjoint, projection operators, parity operator, commutator algebra, uncertainty relations between two operators, eigen values and eigen vectors, unitary transformations, Matrix representation of kets, bras and operators, Change of basis and unitary transformations, wave functions in position and momentum space, Matrix representation of eigen value problem, Dirac delta function

Unit 2 **Postulates of Quantum Mechanics**

The basic postulates of Quantum Mechanics, Representation of state, representation of dynamical variables, Observables and operators, measurement in Quantum Mechanics, time evolution, stationary state, Schrodinger equation and wave packets, conservation of probability, expectation value, Ehrenfest theorem, symmetries and conservation laws

Unit 3 **One-dimensional and three-dimensional Problems**

The free particle, the particle in a box, The potential step, infinite square well, finite square well, The Harmonic oscillator by analytic and operator method, Hermite polynomials, harmonic oscillator wave functions, correspondence with classical theory, Spherically symmetric potentials in three dimensions, the spherical square well potential, the hydrogen atom, energy quantization, quantum numbers

Unit 4 **Angular Momentum**

Orbital angular momentum, general formalism of angular momentum, raising and lowering operators, matrix representation of angular momentum, Eigen functions and Eigen values of L^2 and L_z using operator method, spherical harmonics, experimental evidence of spin, general theory of spin, spin $\frac{1}{2}$ and Pauli spin matrices



Unit 5 **Addition of Angular Momenta**

Rotations in Classical Physics, rotations in Quantum Mechanics, Addition of two angular momenta, Clebsch-Gordon coefficients, coupling of orbital and spin angular momenta, tensor operators, spherical tensors, Wigner-Eckart theorem

Unit 6 **Identical Particles**

The principle of indistinguishability; Symmetric and anti-symmetric wave functions; Spin and statistics of identical particles; The Slater determinant; The Pauli exclusion principle; Spin states of a two electron system; States of the helium atom; Collision of identical particles.

Recommended Books

1. Quantum Mechanics by Nouredine Zettili (Wiley) 2nd Ed., 2004
2. Quantum Mechanics by Franz Schawbl Springer 4th Ed. 2007
3. Introductory Quantum Mechanics by Liboff, Pearson Education India, 4th Ed. 2003
4. Quantum Mechanics by Claude Cohen-Tannoudji, Bernard Diu, Franck Laloe Vol. I & II, Wiley-CH, 1997
5. Quantum Mechanics, by L. I. Schiff, McGraw-Hill Inc.,US, 3rd Revised Ed.
6. Introduction to Quantum Mechanics by David Griffiths, Pearson Education; 2nd Ed. 2015
7. Quantum Mechanics, by A. K. Ghatak and S. Lokanathan (Macmillan -India), 5th Ed.
8. Quantum Mechanics by Mathews and Venkatesan, 2nd Ed. 2010



Theory Tutorials
PH – 421: QUANTUM MECHANICS - I
(Discussion and problem solving/exercise sessions)

1. Insignificance of de Broglie hypothesis in macrophysics
2. General procedure to write down the Schrödinger equation for any system
3. Square potential barrier, quantum mechanical tunnelling
4. Relations giving the values of the commutators
5. Plotting of harmonic oscillator wave functions
6. Interpretation of hydrogen atom wave-functions
7. Problems in three dimensions : Anisotropic and Isotropic Oscillators
8. The algebra of rotation generators
9. Addition of angular momenta; L, S, J values for various atoms in periodic table.

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference Books.



PH-422- Solid State Physics**Unit 1 Crystal Physics**

Crystal classes and Systems, Lattice, Lattice Points and space lattice, unit cells and lattice parameters, 2D and 3D lattices, Symmetry and Symmetry operations, Directions, Planes, and Miller Indices, Reciprocal lattices, Brillouin Zones, Ideal and real crystal, Temperature dependence of reflection lines. Elastic scattering from Surfaces; Elastic scattering from amorphous solids.

Unit 2 Crystal Defects

Different type of imperfections, Schottky and Frenkel defects, edge and screw dislocations, Grain boundaries and stacking fault. X-Ray diffraction, Powder Crystal method, Rotating Crystal method, Laue methods, other probes for Crystal Structure determination.

Unit 3 Lattice vibrations and thermal properties

Vibrations of Monoatomic Lattice, normal mode frequencies, dispersion relation. Lattice with two atoms per unit cell, normal mode frequencies, dispersion relation., Quantization of lattice vibrations, phonon momentum, Inelastic scattering of neutrons by phonons, Surface vibrations, Inelastic Neutron scattering. Anharmonic Crystal Interaction. Thermal conductivity - Lattice Thermal Resistivity.

Unit 4 Diamagnetism and Paramagnetism

Langevin diamagnetic equation, diamagnetic response, Quantum mechanical formulation, core diamagnetism. Quantum Theory of Paramagnetism, Rare Earth ions, Hund's Rule, Iron Group ions, Crystal Field Splitting and Quenching of orbital angular momentum; Adiabatic Demagnetisation of a paramagnetic Salt, Paramagnetic susceptibility of conduction electrons.

Unit 5 Magnetic ordering

Ferromagnetic order- Exchange Integral, Saturation magnetisation, Magnons, neutron magnetic scattering; Ferrimagnetic order, spinels, Yttrium Iron Granets, Anti Ferromagnetic order.

Ferromagnetic Domains - Anisotropy energy, origin of domains, transition region between domains, Bloch wall, Coercive force and hysteresis.

Unit 6 Superconductivity

Historical Introduction, Superconducting Materials, Josephson effect, The London Equation, Ginzburg-Landau theory, The BCS theory, HTSC cuprate Material Characterisations properties of HTSC Oxides, Potential Applications of Super Conductivity.

Reference Books:

1. Introduction to Solid State Physics by Kittel, John Wiley & sons, 7th ed.
2. Fundamentals of Solid State Physics by J.Richard Chistman John Wiley & sons
3. Solid State Physics - Structure and properties of Materials by M.A. Wahab Narosa Publications 1999.
4. Elementary Solid State Physics by M. Ali Omar, Addison Wesley (LPE)
5. Solid State Physics- S.O. Pillai (3rd edition), New Age International Ltd.

Theory Tutorials

**PH - 422 : SOLID STATE PHYSICS
(Discussion and problem solving/exercise sessions)**

1. Review of Crystal Structure.
2. Space Group & Point Groups.
3. X-Ray diffraction Structure factor.
4. Phase diagrams of Binary alloys.
5. Problems on magnetic materials.

In addition to above the tutorial will also consist of solving problems given in the text and reference books.

M.Sc.- (Physics)- Semester - II

PH-423: Classical Electrodynamics and Plasma Physics



Unit 1 Multipole expansion

Multipole expansions for a localised charge distribution in free space, Linear quadrupole potential and field, static electric and magnetic fields in material media, Boundary conditions.

Unit 2 Maxwell's equations

Displacement current, Maxwell's equations, Maxwell's equations in matter, boundary conditions, The continuity condition, Poynting's theorem, Maxwell's stress tensor

Unit 3 Electromagnetic waves

Waves in one dimension, boundary conditions: reflection and transmission, polarization, Electromagnetic waves in Vacuum, energy and momentum in electromagnetic wave, Electromagnetic waves in matter, Reflection and transmission at normal and oblique incidence, Electromagnetic waves in conductors, frequency dependence of permittivity, skin depth

Unit 4 Potentials and fields

Scalar and vector potential, Gauge transformations, Coulomb and Lorentz gauge, Retarded potentials and Lienard-Wiechert potentials, the fields of a moving point charge

Unit 5 Wave Guides

Rectangular wave guides, Transverse magnetic waves in rectangular wave guides, transverse electric waves in rectangular wave guides, TM and TE waves in circular wave guides

Unit 6 Plasma Physics and magnetohydrodynamics

Introduction of plasma physics and magnetohydrodynamics, magneto-hydrodynamic equations, magnetic diffusion, viscosity and pressure, magneto hydrodynamic flow between boundaries with crossed electric and magnetic fields, pinch effect, instabilities in a pinched plasma column, magneto hydrodynamic waves, plasma oscillations, Debye screening. Applications of plasma physics and controlled thermonuclear reactions.

Recommended Books

1. Introduction to Electrodynamics by David J. Griffiths



2. Classical Electricity and Magnetism by Panofsky and Phillips
3. Classical Electrodynamics by J. D. Jackson
4. Electromagnetic waves and Radiating systems by Jordan and Balmain
5. Foundations of Electromagnetic Theory by Reitz and Milford
6. An Introduction to Magnetohydrodynamics by P A Davidson, Cambridge University Text, 2001
7. Introduction to Plasma Physics and Controlled Fusion by F F Chen, Springer; 2nd ed. 1984

Theory Tutorials

PH – 423: CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS (Discussion and problem solving/exercise sessions)

1. Calculation of multipole moments of discrete and continuous charge configuration.
2. Problem involving gauge other than Coulomb and Lorentz gauge.
3. Problem monopole and charge quantization.
4. Problem on Brewster angle, spreading of a wave propagating in a dispersive medium,
5. Problem on magnetic flux through a perfectly conducting loop.
6. Problem of net force on the hemisphere of uniformly charged solid sphere using Maxwell's stress tensor.
7. Problems on reflection and transmission coefficients
8. Energy associated with the skin depth of a conductor.
9. Radiation due to a cube with charge at alternate corners.
10. Problems on TE modes

In addition to above the tutorial will also consist of solving problems given in the text and reference books.

M.Sc.- (Physics)- Semester - II

PH- 424: Numerical Analysis and Computer Programming



Unit 1 Numerical Integration:

Newton-Cote's formula, Trapezoidal, Simpson $1/3^{\text{rd}}$ and $3/8^{\text{th}}$ rule and Weddle rules.

Numerical Solutions of Ordinary Differential Equations:

Euler, Picard and Taylor series methods, Runge–Kutta 2^{nd} order and 4^{th} order method, and Predictor Corrector methods

Unit 2 Solution of Simultaneous Linear Equations:

Matrix inversion method, Cramer's rule with Pivotal and triangle methods for determinants.

Eigenvalues and Eigenvectors of a Matrix:

Characteristic roots method, Jacobi method, Householder method.

Unit 3 & 4 Operating systems, higher level compiler languages, algorithm; flow charting, FORTRAN Language

Character set, structure of a program, constants and variables, arithmetic expressions, arithmetic statement; assignment statements, input and output statements, control statements: IF-THEN-ELSE, arithmetic IF, logical expressions and assignments, GO TO, basic looping structure, Subscripted variables, DIMENSION statements; format specifications; OPEN and CLOSE statements; function statements, function subprograms and subroutines

Unit 5 & 6 C-Language:

Introduction to C language, identifiers and keywords, data types, constants and variables, arithmetic expressions; input and output statements, conditional statements: *while*-loop, *for*-loop, *do while*-loop; arrays; logical operators and expressions, structures: *switch*, *break* and *continue* statements; functions; structures; pointer data type; random and sequential files, file handling in C.

Programs:

Program writing in FORTAN and C for interpolation, integration, roots of equations, matrix diagonalization, solution of differential equations. Good programming practices.

Recommended Books

1. J. B. Scarborough, Numerical Mathematical Analysis, Oxford Books Co., 1962.



2. S. S. Sastry, Introductory Methods of Numerical Analysis. PHI, 1998.
3. K. S. Rao. Numerical Methods for Scientists and Engineers, PHI, 2001
4. V. Rajaraman, Computer Oriented Numerical Methods, PHI, 1994.
5. J. H. Mathews, Numerical Methods for Math., Science and Engineering, PHI, 1994
6. V. Rajaraman, Computer Programming in FORTRAN 77, PHI, 1994.
7. P. S. Grover, Programming and computing with FORTRAN 77 and 90.
8. V. Rajaraman, Computer Programming in C, PHI, 1997.
9. C. Xavier, C Language and Numerical Methods, 1999.
10. B.W. Kernigham and D.M. Ritchie, The C Programming language, PHI, 1988.

Theory Tutorial

(Discussion and Problem Solving Sessions)

1. Error in numerical computation, error in construction of a model, approximations.
2. Truncation error and their estimation.
3. Propagated rounding error and methods to minimize it.
4. Order of convergence of iterative procedures.
5. Analysis of errors in various interpolation formulas.
6. Errors in computed eigenvalues and eigenvectors.
7. Flow charts
8. Elementary programs using FORTRAN.
9. Elementary programs using C.

M.Sc.- (Physics)- Semester - II

PH- 425: Practicals



1. Numerical Analysis-III
2. Numerical Analysis-IV
3. Computer Experiment –II
4. 'e' by Milliken's Oil drop Method
5. Electron Spin Resonance
6. Measurement of Susceptibility of Liquid by Quinck's Methods
7. Lattice Dynamics
8. X-Ray Diffraction
9. Transducers-II
10. Electrical Conductivity of a Semiconductor using Four Probe Method.
11. Photo Cell
12. Measurement of 'h' by Solar Cell
13. Design build and test an Astable multivibrator
14. Design build and test a phase shift oscillator using operation amplifier
15. Design build and test regulated power supply.
16. Design build and test combinational logic circuit using multiplexer.
17. Design, build and test 4 bit R-2R ladder type DAC
18. To design, build and test a first order band pass filter using operational amplifier.

