

VEER NARMAD SOUTH GUJARAT UNIVERSITY

M.Sc. Part – I

Physics

(In force from – 1999)

Each paper will be for 100 marks and of three hours duration. There will be three practicals each of three hours duration and total marks for practicals will be 200.

Paper – I : Section-I : Classical Mechanics
 Section-II : Electrodynamics

Paper – II : Section-I : Quantum Mechanics
 Section-II : General Electronics

Paper-III : Section-I : Mathematical Methods in Physics
 Section-II : Solid State Physics

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M.Sc. Part – I

Physics

Part – I

(Classical Mechanics and Electrodynamics)

Section - I

Classical Mechanics

Review mainly through examples of Newton's laws of motion, inertial frames of references, conservative force fields, conservation laws of momentum, angular momentum and energy, non-inertial frames, Coriolis force, motion relative to earth. Conservation laws for a system of particles, limitations of Newton's programme.

Generalized coordinates, Hamilton's principle, and Lagrange's equations of motion for conservative and non-conservative system. Velocity dependent potentials and the dissipation/ constraints / functions Lagrange undetermined multipliers, advantages of variational principles formulation, conservation theorems and symmetry properties, ignorable coordinates, equivalence of Lagrange's and Newtons' equations, canonical equations of motion, Routh's procedure particles in an electromagnetic field, principle of least action.

Canonical transformations, examples, Poisson Brackets, quantum Poisson brackets, infinitesimal canonical transformation, constants of motion and symmetry properties. Hamilton-Jacobi equation, action angle variables, separation of variables in H-J equations, examples, symmetry groups of mechanical systems.

Central force field problem, reduced mass, equation of motion, orbits in central force fields, Kelper's laws, Scattering in a central force field, physics of tides, transformation from c.m. to laboratory system. Rigid body motion, Euler-angles, moments and products of inertia, Euler's and Lagrangian treatment of rigid body motion, force free motion of a symmetrical top, motion of a symmetrical top with one point fixed, procession of equinoxes and satellite orbits, dynamics of some sports, small oscillations, eigen-value equation, normal coordinates, examples, forced vibrations.

Fluid dynamics, Bernoulli's theorem, applications, gravity waves and ripples, flow of imperfect fluids.

Recommended Books

1. H. Goldstein, Classical Mechanics, Addison Wesley, 1980.
2. B.I. Sheth, Prashishta Yantra Shashtra, University, Book Production Board, Ahmedabad, 1976.
3. L.D. Landay and E.M. Lifshitz, Mechanics, Pergamen Press, 1976.
4. D. Ter Haar Elements of Hamiltonian Mechanics, Pergamen Press, 197.
5. N.C. Rana and P.S. Joag, Classical Mechanics, TMH, 1991.
6. J.B. Marion and S.T. Thronton, Classical Mechanics, HBJ Pub., 1988.

Section – II

Electrodynamics

Coulomb's Law, electric field, Gauss's law, scalar potential, Poisson's and Laplace's equations, solutions of Laplace's equation in rectangular, spherical and Cylindrical co-ordinates, simple applications of Laplace's and Poisson's equations, uniqueness theorem about solution, method of images, orthogonal functions and expansions, Green's function, eigen function expansion for Green's function, multipole expansions of the potential of a charge distribution and energy of a charge distribution in an external field, simple dielectric and boundary conditions, electrostatic energy in dielectric medium, electrostatics for macroscopic media.

Magnetostatics, Biot-Savart law, Ampere's law, vector potential, magnetic multipoles, vector potential and magnetic induction for a circular current loop, magnetic moment, force and torque on and energy of a localized current distributions, boundary conditions in an internal magnetic induction, macroscopic equations, boundary in magnetostatics, uniformly magnetized spheres, magnetic shielding, Maxwell's displacement current, Maxwell's equations, scalar and vector potentials, gauge transformations, Poynting's theorem, macroscopic equations, plane waves in a non-conducting medium, polarization, superposition of waves in one dimension, group velocity, plane waves in conducting medium, skin depth, radiation from antenna, antenna arrays, wave guides, rectangular wave guides, modes in rectangular wave guides.

Magneto hydrodynamics and plasma physics, introduction, 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 distance.

Recommended Books

1. J.D. Jackson, Classical Electrodynamics, Wiley Eastern, 1975.
2. W.K.H. Panofsky and M. Philips, Classical Electricity and Magnetism, India Book Co., 1970.
3. E.C. Jordan and K.G. Balmain, Electromagnetic Waves and Radiating Systems, Prentice Hall, 1985.
4. J.B. Marion, Classical Electromagnetic Radiation, Academic Press, 1965.

Theory Tutorials

(These are mainly problem solving sessions Concepts and other relevant aspect of theory course can also be discussed)

Section - I

1. Examples of systems with different degrees of freedom, constraints.
2. Examples of Hamilton's principle
3. Examples of Lagrangian formulation.
4. Examples of Hamiltonian formulation, Hamiltonian which are conserved/ total energy/ time dependent.
5. Routhian
6. Motion of bodies under central forces which are not inverse square.
7. Hard sphere scattering, problem on scattering.
8. Symmetric top using Euler's equations, moments of symmetric rigid bodies about their axis of symmetry.
9. Examples of small oscillations, normal modes.
10. Examples of Hamiltonian formulation.
11. Examples of using action – angle variables.
12. Examples of canonical transformations.
13. Transition from classical Poisson bracket to commutator brackets, Poisson bracket involving angular momentum.

Section – II

1. Calculation of charge density for a given potential function. Mean value theorem for electrostatic potential.
2. Problems on method of images.
3. Calculation of multipole moments of discrete and continuous charge configuration. Interaction energy of a nucleus in an external field.
4. Problems in magnetostatics.
5. Rotating metal disc in a uniform magnetic field. Problem on Hall Effect, magnetic held inside a coaxial tube.
6. Problem involving gauge other than Coulomb and Lorentz gauge.
7. Magnetic monopole and charge quantization.
8. Problem monopole and charge quantization.

9. Problem on Brewster angle, spreading of a wave propagating in a dispersive medium, problem on spherical wave.
10. Energy associated with the skin depth of a conductor. Radiation due to a cube with charge at alternate corners.
11. Linaard – Wienchart potential due to a charge in uniform circular motion.

VEER NARMAD SOUTH GUJARAT UNIVERSITY

M.Sc. Part – I

Physics

Paper – II

(Quantum Mechanics and General Electronics)

Section - I

Quantum Mechanics

Inadequacy of old quantum theory, DeBroglie waves and wave particle duality, vectors and operators, hermitian operators, projectors, Hilbert space, expansion postulates, commuting operator, Heisenberg's uncertainty relation, postulates of quantum mechanics, Schrodinger picture, Heisenberg picture, representation, wave mechanics, Schrodinger equation, wave function, probabilistic interpretation, stationary states, one dimensional problems piecewise constant potentials, periodic potential, penetration of potential barrier, harmonic oscillator, free particle, momentum eigen function.

Harmonic oscillator by operator method, angular momentum operators, commutation rules, eigen-values and eigen-functions, hydrogen atom, three dimensional harmonic oscillator, matrix formulation of quantum mechanics, spin, Pauli spin operators, spin precession, spin-orbit interaction and spin correction for hydrogen atom, addition of angular momenta, Clebsch-Gordan coefficients.

Schrodinger perturbation theory for non-degenerate and degenerate levels perturbed harmonic oscillator, normal and anomalous Zeeman effect, Stark effect, time-dependent perturbation theory, variational method.

Scattering of particles with spin and exclusion principle scattering of identical particles identity and isotopic spin.

Klein-Gordon equation, Dirac's equation, Spin and magnetic moment of the electron reduction of Dirac equation to non-relativistic limit, difficulties of relativistic equations for a single particle, quantization of field, quantization of non-relativistic Schrodinger field.

Recommended Books

1. E. Merzbacher, Quantum Mechanics, Willey, 1970.
2. A. Messiah, Quantum Mechanics Vol.I, North Holland, 1972.
3. P.M. Mathews and K.B. Venkatesan. A Textbook of quantum Mechanics, TMH, 1981.
4. A.K. Ghatak and S. Lokanathan, Quantum Mechanics, Macmillan (India), 1979.
5. L.I. Schiff, Quantum Mechanics, McGraw, Hill, 1968.
6. S. Datta Majumdar, Vikas publishing, 1995.

Section - II

General Electronics

Network Analysis node and loop methods, matrix method, graph and trace of network, two and four terminal networks, network theorems, network parameters, transient response of R-L and R-C circuits.

Operating point, bias stability, stabilization against I_{CO} , VEB and bias compensation, thermistor and transistor compensation, thermal runaway, thermal stability, heat sink theory, heat sink characteristics and its selection, thermal fatigue, bias for emitter follower.

Classes of amplifiers, harmonic distortion, methods of calculating harmonic distortion, square wave testing, gain frequency plots of amplifier response, phase plot, bandwidth of cascade amplifiers, bandwidth criteria for the transistor, gain-bandwidth product composite amplifier designs, bootstrapping the FET, multiple stage feedback, amplifier stability with feedback, gain and phase margin, analytical considerations in stability amplifier noise figure, noise in amplifier.

Integrated amplifiers, the differential amplifier, rejection of common mode signals, a constant current replacement of R_E , DC level shifter, a complementary output stage, the operational amplifier, input and output impedances, frequency compensation, slew rate, input-offset voltage, input offset current, unity gain buffer, adding operation, integration operation, comparator, analog, computation, logarithmic amplifier, nonlinear function generator, voltage regulator using integrated amplifiers, square wave and triangular wave generators, time IC circuit (555) and its applications, simulation of inductance.

FET, small signal model, biasing FET, as VCR.

Band pass amplifiers, pole zero diagram, signal tuned amplifier-root locus, inductively coupled circuits, tuned primary amplifier, tuned secondary FET amplifier, response to pulses bandwidth requirement for pulse amplification rise time in pulse amplifier, sag of the pulses, shunt-peak video amplifier, rise time to shunt peaked amplifier, a differential pair as a wide band amplifier.

Implementing logic circuits with NAND, NOR gates, logic functions, Karnaugh, maps. Simplification of logic functions using K-maps, combinatorial digital circuits, gate assemblies, binary adders, arithmetic functions, digital, comparator, parity checker-generator, decoder-demultiplexer, data selector-multiplexer, encoder, ROM two-dimension and addressing of ROM, ROM applications.

Sequential digital systems, 1-bit memory, 1-bit clocked S-R flip-flops, J-K, T and D type flip-flops, shift registers, ripple counters, application of counters.

Series and shunt voltage regulation, zener diode and transistor regulator circuits, principle of electronic feedback regulators, design of regulated power supplies, VTVM CRO (single, dual, and storage), multi vibrators, thermistors.

Recommended Books

1. J.D. Ryder, Electronic Fundamentals and Applications, Prentice Hall of India, 1981.
2. J. Millmann C. C. Halkias, Integrated Electronics, McGraw Hill, 1981.
3. A. Mottershed, Electron Devices and Circuits, Prentice Hall of India, 1981.
4. J. Millmam and A. Grabel Microelectronics, McGraw Hill, 1987.
5. A.S. Sedra and R.C. Smith Microelectronics circuits, Oxford (Indian Reprint), 1995.

: Theory Tutorials :

(These are mainly problem solving sessions. Concept in theory and related aspects can also be discussed).

Section-I

1. Insignificance of deBroglie hypothesis in macrophysics, Key ideas of quantum mechanics, uncertainly relation between conjugate variables.
2. Ehrenfest theorems; expectation value, orthogonality and normalization of waves functions.
3. One dimensional problems (H. Osc., step potentials etc.)
4. Problems in two and three dimensions
5. Interpretation of hydrogen atom wave-functions
6. Operator algebra, parity operator and its eigenvalues. Does parity operator commute with Hamiltonian.
7. Problems on angular momentum spin
- 8-9. Problems of non-degenerate and degenerate time-independent perturbation theory.
10. Problems on scattering theory including born approximation.
11. Problems on variational method.
12. Identical particles
13. Hydrogen atom using K-G and Dirac equations.

Section-II

1. Calculation of quiescent point, drawing of load line, computation of base input resistance and collector load resistance, calculation of transistor parameters from the graphs of characteristics.
2. Designing of JFET switches
3. Calculation of stability factor for various biasing networks, Bode's plot
4. Design and analysis of function generator
5. Design of a square wave circuit using logarithmic amplifier.
6. Calculation of average and output resistance of FET, choice of gain for matching input/ output impedances.
7. Example of thermal designing of a heat sink.
8. Design of an amplifier with specified input or output resistance.
9. Solving Boolean expressions

10. Applications of K Map
11. Design of 7 – segment display
12. Design of decoders
13. Applications of counters
14. Analysis of a monostable multivibrator circuit using NOR gates.

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M.Sc. Part – I

Physics

Paper – III

(Mathematical Methods in Physics and Solid State Physics).

Section-I

Mathematical Methods in Physics

Ordinary differential equations, solution in closed form, power series solution, miscellaneous approximate methods the W K B method.

Integral transforms, Fourier transforms, Laplace transforms, other transform pairs, applications of integral transforms.

Special functions, Legendre functions, Bessel functions, hyper geometric functions, confluent hyper geometric functions. Hermite functions, spherical harmonics, Langerre's functions.

Partial differential equations examples, general discussion, separation of variables, integral transform method.

Introduction to groups and group representations, definitions, sub-group and classes, group representation, characters, physical applications, infinite groups, SU(2), SU(3).

Review of residue theorem, contour integration and evaluation of definite integrals, conformal mapping.

Numerical methods, finite differences, difference tables, interpolation, roots of equations.

Binomial, poisson and Gaussian distribution, properties of distributions, fitting of experimental data.

Recommended Books

1. J. Mathew R.L. Walker, Mathematical Methods of Physics Benjamin (IBH) 1979.

2. H. Margenau and G.M. Murphy, Mathematics of Physics and Chemistry, East-West Press, 1975.
3. P.M. Morse and H. Feshbach, Methods of Theoretical Physics, Vols.1-2, McGraw Hill-Kogekusha, 1953.
4. V.M. Trivedi, Ganitiya, Bhautikshashtra, Vol.3, Univ. Book Production Board, Ahmedabad, 1974.
5. D.D. Desai, Ganitiya Bhautikshashtra, Vol.2, Univ. Book Production Board, Ahmedabad, 1978.
6. R.V. Churchill, Complex Variables, and Applications, McGraw Hill, 1960.
7. Mathematical Physics, B.S. Rajput Pragati Prakashan, 1997.

Section-II

Solid State Physics

Drude theory of metals, basic assumptions of the model, collision or relaxation times, dc electrical conductivity, Hall-effect and magneto resistance, AC electrical conductivity, thermal conductivity, Sommerfeld theory of metals, ground state properties of electron gas, thermal properties of free electron gas, Sommerfeld theory of conduction, Wiedmann-Franz law, failure of the free electron model.

Crystal lattices, Bravais lattice and primitive vectors, simple, body-centered and face-centered cubic lattices, primitive unit cell, Wigner-Seitz cell, conventional cell, crystal structure and lattice with bases, hexagonal close packed and diamond structures, sodium chloride, cesium chloride, zinc blende structures, reciprocal lattice, definitions and examples, first Brillouin zone, lattice planes, miller indices, determination of crystal structures by X-ray diffraction, formulations of Bragg and Von Laue, their equivalence, Laue condition and Ewald's construction, Laue, rotating crystal, powder, experimental methods, geometrical structure factor, atomic form factors, classification of Bravais lattices and crystal structure.

Electron levels in a periodic potential, periodic potential and Bloch's theorem, Born-von Karman boundary condition, second proof of Bloch's theorem, general remarks about Bloch's theorem, Fermi surface, periodic potentials in one dimension (problem) crystal momentum, band index velocity, Fermi surface, perturbation theory and weak periodic potentials energy levels near a single Bragg plane, energy bands in one dimension and Fermi surface and Brillouin zones.

Tight binding method, general formulation, application to bands from S-levels, general remarks on tight-binding method.

Classification of solids, classification of insulators, ionic crystals, alkali halides, II-VI ionic crystals, III-V crystals, molecular crystals, hydrogen-bonded crystals.

Vibrations of monatomic and diatomic linear lattice, acoustical and optical phonons, lattice thermal conductivity phonon-phonon scattering, geometrical scattering.

Homogeneous and inhomogeneous semiconductors, general properties of semiconductors, examples of semiconductors, typical semiconductor band structures, cyclotron resonance, number of carriers in thermal equilibrium, extrinsic case, impurity levels, semi classical treatment of inhomogeneous solids, P-N junction in equilibrium, elementary picture of rectification by P-N junction.

Pauli Paramagnetism, conduction electron diamagnetism measurement of Pauli paramagnetism, electron diamagnetism in doped semiconductor, electrostatic origins of magnetic interactions, magnetic dipole-dipole interaction energies, magnetic properties of a two electron system, failure of independent electron approximation. Spin thermodynamic properties at onset of magnetic ordering, ground state of Heisenberg ferromagnet and antiferromagnet, spin waves, mean field theory, domains.

Superconductivity, superconducting elements, critical temperature, persistent currents, thermoelectric and magnetic properties, critical field, specific heat, other manifestations of the energy gap, London equation, BCS theory, qualitative features, prediction of elementary BCS theory, Meissner effect, Josephson effects.

Recommended Books

1. N.W. Ashcroft and N.D. Mermin, Solid State Physics, Holt-Saunders International Editing 1981.
2. C. Kittel, Introduction to Solid State Physics (7th Ed.) Wiley, 1996.
3. A. J. Dekker, Solid State Physics, MacMillan (India), 1981.
4. W. A. Harrison, Solid State Theory, TMH, 1970.

: Theory Tutorials :

(Theory are problem solving and discussion sessions. Concepts in theory and related aspects can be discussed).

Section – I

1. Applications of series solution method
2. Application of W.K.B. method
3. Problems of method of separation of variables for PDE.
4. Problems of hyper geometric and confluent hyper geometric functions.
5. Addition theorem of spherical harmonics
6. Residue theorem applications
7. Contour integration
8. Evaluation of definite integrals using contour integration.
9. Problems on numerical methods
10. Problems on distributions
11. Constructing character tables
12. Representation theory of groups
13. $S U (2)$, $S U (3)$ – applications

Section – II

1. Review of crystal structure
2. Space groups and point groups
3. X-ray diffraction structure factor
4. How to read band diagrams
5. Review of phase diagrams of binary alloys
6. Spin glass
7. Problems of lattice dynamics
8. Problems on multiple crystal structure etc.
9. Information from cyclotron response
10. Crystal defects and their propagation

11. Thermistors and their properties
12. Applications of superconductivity
13. High temperature super conductivity and its applications
14. Problems of magnetism (dia, para, ferro, ferri)
15. Problems on semiconductor, P - Njunction.

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M.Sc. Part – I

Physics

Laboratory Experiments

1. Micholson's Interferometer
2. Fabry-Perot's Interferometer
3. Numerical Methods – I (work session)
4. Numerical Methods – II (work session)
5. Hall Effect
6. Wave Guide
7. Computer Experiment: To verify Kepler's Laws
8. Computer Experiment: Kronig – Penny Model, Anharmonic oscillator
9. Fourier Analysis
10. Lattice Dynamics
11. Ultrasonics - I
12. Ultrasonics – II
13. Energy Gap of a semiconductor
14. Electrical resistivity concerning of a semi conductor by four – probe method
15. Electrical conductivity of graphite
16. Conductivity of a semi conductor
17. E/m nellicall/ Thomson method
18. e by millikan's oil drop method
19. Measurement of susceptibility by Quinck's method
20. X-ray Diffraction
21. Study of distributions (work session)
22. Recurrence relation for Legendre and Hermite Polynomials (work session)
23. Generating function for Legendre and Hermite polynomials (work session)
24. Operational Amplifier (I, II)
25. To design, build and test oscillator using UJT
26. To design, build and test active filters
27. To design, build and test onstage FET amplifier
28. To design, build and test astable multivibrator
29. To design, build and test regulated power supply

30. To design, build and test half adder and subtractor
31. To design, build and test multiplexer
32. To design, build and test counter using J-K flip flops
33. Normal modes (coupled pendulum)
34. Random delay
35. Photocell
36. Quadrant oscillator
37. by photocell

Laboratory Experiments

This is a kind of group instruction in a formal manner as a part of laboratory programme for personal participation and discussion. The tutorials will involve.

- (i) General instructions about the experiment, group of experiments, group of experiments and relevant apparatus equipment etc.
- (ii) Discussion on analysis of data, precision of measurement limitations of equipment and methodology of measurement.
- (iii) Industrial applications of experimental skills developed, local needs and relationship with physics studied.
- (iv) Possible demonstration experiments.

Tutorials will also include the following topics for discussion/ demonstrations:

1. Techniques of designing and layout of complex PCB's, soldering skills, testing of circuits for appropriate and required functioning.
2. Fault finding and repairs
3. Use of sensors/ transducers, gauges and gadgets needed for the measurement of temperature, pressure, electrical, electronic, optical and magnetic parameters.
4. Gyroscope and applications
5. Turbulence
6. Voltage controlled oscillator
7. Effects of capacitance and load resistance on output of an amplifier
8. Experimental methods of obtaining phase diagrams
9. Antiferromagnetic materials
10. Sub groups
11. Occurrence of Legendre and Hermite polynomials in physical problems
12. Methods of determining susceptibilities.