

VEER NARMAD SOUTH GUJARAT UNIVERSITY

M.Sc. (Tech) Part – I

Applied Physics

(In force from June–2000)

Each paper will be for 75 marks (scheme 52/54 ext. 23/21 int.) and three hours duration. There will be three practicals each of three hours duration and total marks will be 200.

Paper – I	:	Section-I	:	Mechanics and its applications
		Section-II	:	Electromagnetic fields and waves
Paper – II	:	Section-I	:	Quantum Mechanics
		Section-II	:	Measurement and Instrumentation
Paper-III	:	Section-I	:	Mathematical Methods
		Section-II	:	Computational Methods and Programming
Paper-IV	:	Section-I	:	Solid State Physics and Applications
		Section-II	:	Microelectronics

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M.Sc. (Tech) Part – I

Applied Physics

Paper – I

Mechanics and Its Applications, Electromagnetic Fields and Waves

Section - I

Mechanics and Its Applications

Brief history of development of mechanics, review of Newton's laws through problems, limitations of Newton's program and a critical look at Newton's laws, dynamics of system of particles, conservation principles of dynamics, equation of motion with variable mass, flight performance of a single stage rocket, two stage rocket, optimization of multistage rocket.

Constraints and their classification, generalized coordinates, velocity, momentum, force and energy, principle of least action and Hamilton's principle, Lagrange's equation of motion using Hamilton's principle, Lagrange's equation for non-conservation and non-holonomic system, Lagrange's equation for impulsive force, ignorable coordinates, integrals of motion, symmetry and conservation laws, problems on Lagrangian method, Hamiltonian, physical significance, Hamilton's equations of motion using Hamilton's principle, Routhian, Poisson bracket and equation of motion, problems of Hamiltonian method, Lagrangian and Hamiltonian in rotating frame, effect of Coriolis force on (i) river flow and air flow on the surface of the earth (ii) projectile motion (iii) atomic nuclei and planetary atmosphere.

Central force, two body problem under central force, Kepler's laws, applications of orbit equation, satellite orbits, communication satellites, initial value problem, orbit parameter, interceptions and rendezvous, basic physics of tides, scattering in a conservative central force field.

Lagrangian equation for system with many degrees of freedom with small displacements, simple examples.

Kinetic energy and angular momentum of a rigid body, Euler's equations, Euler angles, Lagrangian treatment of rigid body motion, force free motion of a symmetric top, precession of equinoxes, dynamics of sports.

Elasticity, stresses and conditions of equilibrium, Hook's law and strain energy function, generalized Hook's law, dynamics of elastic bodies.

Fluids, basic definitions, central problems of fluid dynamics, equation of state, equation of continuity, equation of motion, Bernoulli's equation, Bernoulli's theorem and its applications.

Optimal control, basic problem on electrochemical process, bang-bang control, height trajectory optimization, optimal economic growth.

Recommended Books

1. A.K. Raychaudhari, Classical Mechanics, Oxford Univ. Press, 1983.
2. S.N. Biswas, Classical Mechanics, Books and Allied, IPI Ltd., 1998.
3. N.C. Rana and P.S. Joag, Classical Mechanics, TMH, 1991.
4. H. Goldstein, Classical Mechanics, Addison Wesley, 19 .
5. બી. આઈ. શેઠ, પ્રશિષ્ટ યંત્રશાસ્ત્ર, યુનિવર્સિટી ગ્રંથ નિર્માણ બોર્ડ, ૧૯૭૬.
6. D.N. B. Ghes, A.M. Devons, Classical Mechanics and control, Ellis Harwood, 1975.

Section - II

Electromagnetic Waves and Fields

Review through problems of vector algebra and vector calculus, Dirac's delta function, Helmholtz theorem, Scalar and vector potential, statement and application of Coulomb's law and Gauss's law, charge distribution, potential of a localized charge distribution, electrostatic boundary condition, energy of a point charge distribution and a continuous charge distributions.

Electrostatic energy, Poisson's equation, Laplace's equation in one, two and three dimensions, uniqueness theorem, method of images, multipole expansion, Gauss law in dielectric, boundary conditions, electrostatic energy in dielectric medium, electrostatic for macroscopic media, special problems involving linear dielectrics.

Biot-Savart law, applications of Ampere's law, comparison of electrostatics and magnetostatics, magnetic vector potential, multipole expansion of magnetic potential, macroscopic equations, boundary conditions on B and H.

Maxwell's displacement current, Maxwell's equations, gauge transformations, Poynting theorem. Solution of Maxwell's equation for charge-free unbounded region, uniform wave, uniform plane waves, relation between E and H in a uniform plane wave, polarization, characteristic wave impedance and propagation constant, wave propagation in a good dielectric and in a good conductor, depth penetration in a good conductor, surface impedance of good conductor to sinusoidal currents, waves incident normally and obliquely on boundary between perfect dielectrics, Poynting vector for a plane wave in a

dielectric, Poynting's theorem, flow of direct current in cylindrical resistor and coaxial cable, Poynting vector with time-varying fields.

Essential conditions for guided waves, TEM wave in coaxial cables and two wire transmission lines, rectangular wave guides electric and magnetic field inside rectangular waveguides, solution of wave equations for rectangular waveguides, transverse electric and magnetic field in rectangular waveguide, cut off frequency wavelength, circular wave guides, retarded magnetic vector potential, magnetic and electric field of oscillating Hertzian dipole, radiation field of Hertzian dipole antenna, directional characteristics of antenna, radiation pattern of dipole antenna, tolled dipole and yagi antenna, antenna arrays, four and eight element arrays.

Recommended Books

1. V.V. Sarwate, Electromagnetic field and waves, Wiley Eastern, 1993.
2. E.C. Jordan and K.G. Balmain, Electromagnetic waves and Radiating Systems, PHI.
3. B.B. Land, Electromagnetics, Wiley Eastern.
4. J.D. Jackson, Classical Electrodynamics, Wiley, 1962.
5. D.J. Griffith, Introduction to electrodynamics, PHI, 1999.
6. M.A. Wazed Miah, Fundamentals of Electronagnetics, TMH, 1982.

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M.Sc. (Tech) Part – I

Applied Physics

Paper – II

Quantum Mechanics and Measurement and Instrumentation

Section - I

Quantum Mechanics

Debroglie hypothesis, waves in quantum mechanics, matter waves and their physical meaning, wave packet, operators, observables, expectation value, commutators, uncertainty principle, time dependent and time independent Schrodinger equation, stationary state, particle in infinite square well, particle in a potential well (finite square well), potential barrier, tunneling phenomena, harmonic oscillator.

Angular momentum, eigenvalue and eigen function for J^2 and J_z , Pauli Spin matrices, addition of angular momentum, Clebsch Gordan coefficients.

Time independent perturbations, transmission line model, perturbation applied to transmission line problem, particle in a modified infinitely deep one dimensional potential well, time dependent perturbation, step function perturbation, harmonic perturbations, electric dipole transitions, periodically loaded transmission line. Spherically symmetric potential, two-body problem, hydrogen like atom problem, degeneracy, vibration and rotation spectra of diatomic molecules.

Two isolated wells, double well potential, ammonia molecule as a two state system, Kronig-Penny model.

Scattering theory, partial wave analysis, Born approximation, scattering from a screened coulomb potential.

Identical particles with spin and exclusion principle, scattering of identical particles, isotopic spin.

Experimental necessity of Dirac's approach, Dirac's equation, spin and magnetic moment of the electron, reduction to non-relativistic limit, difficulties associated with single particle relativistic equations.

Recommended Books

1. P.A. Lindsay, Introduction to Quantum Mechanics for Electrical Engineers, McGraw Hill, 1967.
2. A.K. Ghatak, Quantum Mechanics, McMillan, 1996.
3. A.K. Ghatak and S.L. Loknathan, Quantum Mechanics.
4. L.I. Schiff, Quantum Mechanics, McGraw Hill.

Section-II

Measurement and Instrumentation

Measurement, generalized measurement system, basic concepts of dynamic measurement, system response, distortion, analysis of repeated measurements, mathematical description of data distribution functions, properties of distribution functions, propagation of errors, analysis of data, chi-square test, correlation coefficient, standard deviation of mean, graphical analysis, multiparameter experiments.

Experimental design, transducers, classification of transducer, transducer characteristics, selection of instrumentation transducers, transducer as an electrical element, measurement methods, temperature transducers, variable-resistor transducer, differential transformer, LVDT, Capacitive, piezoelectric and photoconductive transducers, photoemissive detectors, photodiode, phototransistor, ionization transducer, magnetic search coil, Hall transducer, digital displacement transducer, strain gauges, different types of strain gauges, theory and applications of strain gauges.

Signal to noise consideration, noise in frequency domain, sources of noise, signal to noise and experimental design, frequent and bandwidth consideration, bandwidth control, signal to noise enhancement, digital correlation and autocorrelation methods, signal recovery, signal filtering, signal averaging, signal coding.

Fundamental concept of an instrument, input and output, configuration of measuring instruments and instrument systems, methods of correction for interfering and modifying inputs, Instrumentation amplifier, basic characteristics, isolation amplifiers, analog signal processing, high-speed A/D, D/A conversions, digital instrumentation FFT, sampling time and aliasing, grounding, shielding.

Stimulated and spontaneous emission, population inversion, methods of population inversion, laser action, laser rate equation for a three level system, various types of solid, liquid and gas lasers, fiber optics, applications of lasers and fiber optics in communication.

IEEE 488 interface bus, use of electronic spread sheet in measurement and instrumentation.

Digital voltmeters and multimeters, psychological testing, polarography, photovoltaic cell, light emitting devices.

Recommended Books

1. M. Sayer and A. Mansingh, Measurement, Instrumentation and experimental design for Physics and engineering PHI, 2000.
2. B.E. Jones, Instrumentation, measurement and control, TMH, 1981.
3. A.K. Sawhney, A course in electrical and electronic measurements and instrumentation, Dhanpat Rai and Sons, 1998.
4. C.S. Rangan, G.S. Sharma, V.S. Mani, Instrumentation, Devices and Systems, TMH, 1983 (1998).
5. J.P. Halman, Experimental Systems, applications and design McGraw Hill, 1990.
6. E.O. Deoblin, Measurement Systems, applications and design, McGraw Hill, 1990.
7. A.J. Diefenderfer, Principles of electronic instrumentation W.B. Saunders (Toppan) 1972.
8. K. Thyagrajan and A.K. Ghatak, Laser theory and applications, McMillan (India), 1984.

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M.Sc. (Tech) Part – I

Applied Physics

Paper – III

Mathematical Methods and Computational Method and Programming

Section - I

Mathematical Methods

Ordinary differential equations, solution in closed form, power series solutions, 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, hypergeometric functions, Confluent hypergeometric functions, Hermite functions, spherical harmonics.

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

Complex variables, derivative Cauchy-Reimann equations, integration, Cauchy's theorem, Cauchy's formula and its derivatives, residue theorem, Contour integration and evaluation of definite integrals.

Mapping, conformal transformations, Numerical methods, finite differences, difference tables, interpolation, numerical integration, numerical solution of differential equations, roots of equations, summing series.

Binomial, Poisson and Gaussian distributions, properties of distributions, fitting of experimental data.

Recommended Books

1. J. Mathew and R.L. Walkar, Mathematical Methods of Physics, Benjamin (IBH), (1979).
2. H. Margenau and G.M. Nurphy, Mathematics of Physics and Chemistry, East-West Press.
3. P.M. Morse and H. Feshback Methods of Theoretical Physics, Vols. 1-2, McGraw Hill Kogakusha, 1953.
4. V.M. Trivedi, Ganitiya Bhautikshashtra, Vol. 4, Univ. Book Production Board, Ahmedabad, 1974.
5. D.D. Desai, Ganitiya Bhautikshashtra, Vol. 4 Univ. Book Production Board, Ahmedabad, 1978.

6. R.V. Churchill, Complex Variables and Applications, McGraw Hill, 1960.
7. D.S. Rajput, Mathematical Physics, Pragati Prakashan, 1997.
8. A.K. Ghatak, Mathematical Physics, McMillan, 1998.

Section – II

Computational Methods and Programming

Errors in interpolation formula. Matrix inversion, Cramer's rules. Eigenvalues and eigenvectors of a matrix, Jacobi method, Householder method, numerical integration, Newton-Cote's formula, Trapezoidal, Simpson and Weddle rules, Gauss-Legendre open quadrature. numerical solutions of ordinary differential equations, Euler, Picard and Taylor series methods, Runge-Kutta and Predictor-Corrector methods, least squares techniques and applications.

Basic components of a digital computer, assembly language, compiler languages, algorithm, flow charting, FORTRAN language character set, structure of a program, constants and variables, types of FORTRAN statements, formats input and output statements, control statements arithmetic replacement statements, arrays, dimension statements, basic looping structure, DO, DO-WHILE, REPEAT-UNTIL, IF-THEN-ELSE, logical expressions and assignments, function subprograms and function subroutines, good programming practices, Do's and Dont's in FORTRAN programming.

Introduction to C language, identifiers and keywords, data types, constants and variables, declarations and statements, representation of expressions, operations and library functions, data input and output statements functions, arrays and pointers, pointer arithmetic, one and two dimensional arrays, pointer representation of arrays introduction to structures, random and sequential files, file handling in C.

Programme writing in FORTAN and C for interpolation, integration, roots of equations, matrix diagonalization, solution of differential equations.

Recommended Books

1. V. Rajaraman, Computer Programming in FORTRAN 77, 1994.
2. C. Xavier, C language and Numerical Methods, 1999.
3. M.J. Maron, Numerical Analysis, Macmillan, 1982.
4. J.B. Scarborough, Numerical Mathematical Analysis.
5. V. Rajaraman, Computer Oriented Numerical Methods, PHI, 1994.
6. S.D. Conte and C. De Boer, Elementary Numerical Analysis.
7. P.S. Grover, Programming and computing with FORTRAN 77, 1990.
8. B.W. Kernigham and D.M. Ritchie, The C Programming language, PHI, 1988.

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M.Sc. (Tech) Part – I

Applied Physics

Paper – IV

Micro Electronics and Solid State Physics and Its Applications

Section - I

Solid State Physics and Its Applications

Crystal lattice, translation symmetry, unit cell, basis and crystal structure, crystal classification, Miller indices, simple lattices, close packed structure, diamond structure, reciprocal lattice, Laue equation Bragg's law, Brioulline zones, structure factor, methods of structure analysis, types of problems, experimental crystal structure determination, diffraction experiments with various particles x-ray interferometry, x-ray topography, diffraction of neutrons.

Lattice dynamics, one dimensional monatomic and diatomic lattices, three dimension lattice, phonons, scattering of neutrons by phonons, phonon spectroscopy, Raman spectroscopy.

Thermal conductivity, normal process, umklapp process, thermal expansion, scatter mechanism for phonons, review of behaviour of phonon conductivity, experiments at low temperature.

Drude theory of metals, electrical conductivity, Hall effect and magnetoresistance, Sommerfeld theory of metals, and electrical conductivity, Weidman-Franz law, failure of free electron model.

Periodic potential, Bloch's theorem, Kronig-Penny Model, reduced zone scheme, effective mass, tight binding approximation, examples of band structure, photoemission spectroscopy.

Diamagnetism and paramagnetism, Pauli paramagnetism and its measurement, ferromagnetism, Heisenberg theory, anti-ferromagnetism, spin waves, magnetostatic spin waves, surface magnetism.

Characteristics, structure and experimental study of Fermi surfaces, quantum oscillations and topology of Fermi surfaces.

Homogenous and inhomogeneous semiconductors, general properties of semi-conductors, examples of semiconductors, doping of semiconductors, Hall effect, cyclotron resonance, conductivity of semiconductors, quantum Hall effect, semiconductor epitaxy.

Ferroelectricity, piezoelectricity, effects of dielectrics, important requirements of good insulating materials, some important insulating materials.

Superconductivity, historical introduction, survey of superconductivity, zero electrical resistance, Meissner effect, magnetic phase diagram, energy gap, flux quantization, type I and II superconductors, London equations, B.C.S. theory, predictions of BCS theory, Josephson effect and tunneling, new superconductors, high TC cuprates, preparation of materials, applications of Low and High temperature superconductors, SQUID, Nanometer physics and microelectronics, lauced semiconductor structures, fine line lithography, marriage of MBE and fine lithography, device implications.

Recommended Books

1. S.O. Pillai, Solid State Physics, New Age International, 1999.
2. R. Dalvin, Introduction to Applied Solid State Physics, Plenum, 1981.
3. D.L. Weaire and C.G. Windsor, Solid State Science, Adam Hilger, 1987.
4. H.V. Keer, Principle of Solid State, Wiley Eastern, 1993.
5. T.V. Ramakrishnan and C.N.R. Rao, Superconductivity Today, Wiley Eastern, 1992.
6. H. Ibach, H. Luth, Solid State Physics, Narosa Publishing House, 1991.
7. C.M. Kachhava, Solid State Physics, Tata McGraw Hill, 1990.
8. A.J. Dekker, Solid State Physics, McMillan.
9. H.W. Ashcroft and N.D. Mermin, Solid State Physics, Holt-Saunders International Editing, 1981.
10. C. Kittel, Introduction to Solid State Physics, Wiley, 1996.

Section-II

Micro Electronics

1. Review of loop, node, matrix methods and network theorems through problems, graph and tree of network.
2. Operating point, bias stability, stabilization against ICO, VEB and bias compensation, thermistor and transistor runaway, thermal stability, heat sink theory, heat sink characteristics and its selection.
3. Classes of amplifiers, harmonic distortion, methods of calculating harmonic distortions, square wave testing, gain frequency plots of amplifier response, phase plot, Amplifier stability with feedback, gain

and phase margin, analytical consideration in stability, noise in amplifier.

4. Integrated amplifiers, the differential amplifier, rejection of common mode signals, a constant current replacement of RE, DC level shifter, a complimentary 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.
5. FET, small signal model, biasing FET as VVR, MOSFET, enhancement MOSFET and its volt-ampere characteristics, MOSFET circuit symbol, small signal operation of the enhancement MOSFET amplifier, MOS analog Switches, CMOS devices. BIFET, BIMOS circuits, three stage operational amplifier, MOS operational amplifier.
6. Implementing logic circuits with NAND, NOR gates, logic functions, Karnaugh maps. Simplification of logic functions using K-maps, use of K-maps, combinational 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.
7. Sequential digital systems, 1-bit memory, 1-bit closed S-R flip-flops, J-K, T and D type flip-flops, shift registers, ripple counters, application of counters.
8. Regulated power supplies, monolithic regulator, switching regulator, additional switching regulator topologies.
9. General analysis of multistage feedback amplifiers, multiloop feedback amplifiers, stability, test for stability, compensation, frequency response of feedback amplifier, the double pole transfer functions.
10. A general form of oscillator configuration, crystal oscillators, voltage time-base generators, step generators, signal processing, sample and hold circuits, analog multiplexer and demultiplexer, A to D and D to A converters, single amplifier, biquad sections, multiple op-amp biquad sections, switched-capacitor filters, exponential amplifier, analog multipliers, precision AC/DC converters.
11. Monolithic integrated circuit technology, planar process, bipolar transistor fabrication, fabrication of FETs, CMOS technology monolithic diodes, metal semiconductor contact, integrated circuit

resistors, capacitors, integrated circuit packaging, characteristics of integrated circuit components, microelectronic circuit lay out.

12. NMOS, inverter, propagation delay of an NMOS inverter, NMOS logic gates, CMOS inverter, CMOS logic gates, emitter coupled logic circuits, programmable ROMs, Erasable ROMs, programmable logic arrays.

Recommended Books

1. J. Millman and A. Grabel, Microelectronics, MacGraw Hill, 1987.
2. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Holt Saunders, Japan, 1982.
3. J. Millman, Microelectronics, McGraw Hill, 1979.
4. D.E. Hodges and H.G. Jackson, Analysis and Design of digital integrated circuits, McGraw Hill, 1983.
5. P.R. Gray and R.G. Meyer, Analysis and design of analog integrated circuits, John Wiley, 1983.
6. J.D. Ryder, Electronic Fundamentals and applications, PHI.
7. A. Mottershead, Electronic Devices and circuits, PHI, 1981.
8. J. Millman and C.G. Halkias, Integrated Electronics, McGraw Hill, 1981.

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M.Sc. (Tech) Part – I

Applied Physics

Laboratory Work

Group B Experiments

NUMERICAL ANALYSIS

1. Interpolation and Inverse Interpolation using Lagrange's formula.
2. Numerical Integration using Simpson's Rule.
3. Roots of Equation using Newton-Raphson Method.
4. Obtaining, Characteristic Roots, & Characteristic Vectors of a Square Matrix by Jacobi Method.
5. Solving Differential Equations using Runge-Kutta Method.

FORTRAN & C PROGRAMMING

6. Writing and Testing Computer Programmes (FORTRAN & C) for above experiment no. 1-5.

Laboratory Work

A. List of Experiments

1. Hall Effect
2. Measurement of Susceptibility
3. Measurement of bandgap (thermistor)
4. To design, build and test two stage R.C. coupled amplifier.
5. To design, build and test bistable multivibrator.
6. Operational amplifier.

7. To design, build and test voltage regular (IC 741)
8. To design, build and test A to D converter.
9. To design, build and test D to A converter.
10. To design, build and test a ROM using diode matrix.
11. To design, build and test RAM memory cell and its conversion to
(i) 4x1 RAM and (ii) 1x4 RAM

B. List of Experiments

1. Interpolation and inverse interpolation using Lagrange's formula.
2. Numerical integration using Simpson's formula.
3. Roots of equation using Newton-Rophson Method.
4. Obtaining characteristic roots, characteristic vectors of a square matrix.
5. Solving differential equations using Runge-Kutta Method.
6. Writing and testing computer programmes in FORTRAN and C for above experiment no. 1-5.

C. Workshop Practice and Technical Skills

1. Simple jobs on lathe and shaping machine; welding; threading.
2. Use of cutting tools, selection of cutting speeds and feeds etc.
3. Use of Milling and grinding machines.
4. Making of printed circuit board, techniques of designing and layout of complex PCB's.
5. Soldering skills.
6. CAD of electronic circuits.
7. Familiarization with maintenance and repairs, fault finding of different equipments.