GUJARAT UNIVERSITY

T.Y.B.Sc.

SYLLABUS FOR THE SUBJECT OF PHYSICS TO BE IMPLEMENTED

(In force from June, 2005)

PAPER VI

(i) Mathematical Physics

(ii) Quantum Mechanics

(iii) Classical Mechanics

(i) Mathematical Physics : General curvilinear coordinates vector operators in orthogonal curvilinear coordinates.

Ref : M. L. Boas, Methods of Physical Sciences, 2nd Edition.

Note : The expressions for Divergence and Curl are not to be derived. Directly expressions are to be given.

Differential Equations : Some partial differential equations in physics, the method of separation of variables, separation of Helmboltz equation in Cartesian coordinates, in spherical polar and cylinderical coordinates. Laplace's equation in various coordinates.

Text : Art. No. (2.1) and (2.2) of Mathematical Physics by P. K. Chattopadhyay, Wiley Estern Limited.

2nd order differential equations : Ordinary and singular points, series solution around an ordinary point, series solution around regular singular point. The method of Frobenius, getting a second solution, alternative method of getting 2nd solution.

Text : Art. (3.1) to (3.5) of P. K. Chattopadhyay mentioned above.

Some special functions : Bessel's functions, Bessels functions of 2nd kind, Henkel functions, speherical Bessel's functions, Legendre polynomials. Associated Legendre polynomials and spherical harmonics.

Text : Art. (5.1 to 5.5) of P. K. Chattopadhyay.

Computers : Complete chapters 1, 2 and 3 of Programming in ANSI C 2nd Ed. by E. Balaguruswamy.

(ii) Quantum Mechanics :

Exactly soluble eigen value problems : The simple harmonic oscillator. The Schrodinger equation and energy eigen values (4.1), The energy eigen functions (4.2), properties of stationary states (4.3), The abstract operator method (4.4), Coherent states (4.5).

Angular momentum and parity : The angular momentum operators (4.6), The eigen value equation for L^2, separation of variables (4.7), Admissibility conditions on solutions, eigen values (4.8).

The eigen functions : Speherical harmonics (4.9), Physical interpretation (4.10), Parity (4.11), Angular momentum in stationary states of systems with spherical symmetry (4.12).

One dimensional square well potential : Solutions in interior region (4.13), Solutions in the exterior Region and Matching (4.14), Solution of the radial Equation : energy levels (4.15), Stationary state wave functions (4.16), Discussion of bound states (4.17), Solution in terms of confluent hypergeometric functions, non localized states (4.18), solution in Parabolic coordinates (4.19), Other problems in three dimentions. The anisotropic oscillator (4.20), the isotropic oscillator (4.21), Normal modes of coupled systems of particles (4.22), A charged particle in a uniform magnetic field (4.23).

Representations, Transformations and Symmetries : Quantum states, state vectors and wave function (7.1), The Hilbert space of state vectors, Dirac notation (7.2), Dynamical variables and Linear operators (7.3), Representation (7.4), Continuous basis - The sehrodinger representation (7.5), Degeneracy. Labelling by commuting observables (7.6), change of basis, Unitary transformations (7.7), Unitary transformation induced by change of coordinate system : translation (7.8), Unitary transformation induced by Rotation of coordinate system (7.9), The algebra of Rotation generators (7.10), transformation of dynamical variables (7.11), Symmetries and conservation laws (7.12), The space inversion (7.13), time reversal (7.14).

Text Book : A text book of Quantum Mechanics by Mathews and Venketeshan Tata McGraw Hill.

Reference : Quantum Mechanics by Ghatak and Loknathan, The Macmilan Company of India Limited.

Quantum Mechanics by F. Schwabl, Narosa Publishing House, New Delhi.

(iii) Classical Mechanics :

Lagrangian Formulation : Constraints (8.1), generalized coordinates (8.2), D'alembert's principle (8.3), Lagrange's equations (8.4), A general expression for kinetic energy (8.5), Symmetries and the laws of conservation (8.6), Cyclic or ignorable coordinates (8.7), Velocity dependent potential of electromagnetic field (8.8), Rayleigh's dissipation function (8.9).

Motion of rigid body : Euler's theorem (10.1), Angular momentum and kinetic energy (10.2), The inertia tensor (10.3), Euler's equations of motion (10.4), Torque free motion (10.5). Molecular rotations of diatomic molecules.

Variational principle : Lagrange's and Hamiltons equations : Configuation space (11.1), Some techniques of calculus of variation (11.2), Applications of the variational principle (11.3), Hamilton's principle (11.4), Equivalence of Lagrange's and Newton's equations (11.5), Advantages of the Lagrangian formulation - Electromechanical analogies (11.6), Lagrange's undetermined multipliers (11.7), Lagrange's equation for non-holonomic systems (11.8), Applications of the Lagrangian method of undetermined multipliers (11.9), Hamilton's equations of motion (11.10), some applications of the Hamiltonian formulation (11.11), Phase space (11.12), Comments on the Hamiltonian formulation (11.13).

Text : Introduction to Classical Mechanics by Takawale and Puranik (Tata McGraw Hill)

Ref : Classical Mechanics by A. B. Bhatia, Narosa Publication.

PAPER VII

(i) Molecular Spectra

(ii) Statistical Mechanics

(iii) Solid State Physics

(i) Molecular Spectra

Types of molecular energy states and molecular spectra

(1) Separation of electronic and nuclear motion : The Born Oppenheimer approximation.

(2) Types of molecular spectra

Pure Rotational Spectra : Salient features of Rotational spectra, Molecular requirement for rotation spectra, experimental arrangement, Molecule as a rigid rotator; explanation of rotational spectra (without the process of solving Schrodinger equation to get energy formula). The non-rigid rotator, Isotope effect. Tuneble lasers and pulse lasers, introductory.

Vibrational-Rotational spectra, salient features of Vibrational-Rotational spectra, Molecule as a harmonic oscillator, Molecule as anharmonic oscillator, Vibrational frequency and force constant for anharmonic oscillator, Molecule as Vibrating rotator : Fine structure of Infra-red bands, Diatomic molecule as symmetric top; Thermal distribution of vibrational and rotational levels.

Raman Spectra, Nature of the Raman effect, experimental arrangement for Raman spectra, Classical theory of Raman effect, Quantum theory of Raman effect, Raman spectra and Molecular structure Infra-red spectra versus Raman spectra. Laser as intense source.

Electronic Spectra, salient features, formation of electronic spectra, Vibrational (Gross) structure of electronic band system in emission, electronic band spectra in absorption, Rotational structure of electronic bands; Rotational structure of three branch bands; observed intensity distribution (vibrational) in band systems : Franck-Condon principle; explanation of intensity distribution in absorption bands from Franck-Condon principle. Explanation of intensity distribution in emission bands : Condon parabola. Line intensities in a band : Rotational intensity distribution.

Classification of Molecular electronic states : Molecular electronic states, Symmetry properties of electronic eigen functions (symmetry classifiction of electronic states)

Fluorescense and Phosphorescence : Luminescence, Mechanism of fluroscent emission, Mechanism of phosphorescent emission. Fluorescenes spectrum compared with Raman spectrum.

Ref : Atomic and Molecular Spectra by Rajkumar (CH : 17, 18, 19, 20, 21, 23 and 24)

(ii) Statistical Mechanics

2.5 Rotational partition function, 2.6 Vibrational contributions to thermodynamic quantities, 2.7 Electronic partition function.

Bose - Einstein and Fermi-Dirac statistics.

3.1 symmetric and antisymmetric state functions, 3.2 Bose-Einstein and Fermi-Dirac distribution, 3.3 weak and strong degeneracy of perfact gases. 3.4 Bose-Einstein condensation

10.3 Paramagnetism : Langevin Brillouin functions, 10.4 Ferromagnetism : Weiss Model 10.5 Some remarks on the quantum theory of magnetic ordering. Imperfact gases and gas condensation (11.1) Van der Waal's equation, 11.2 Second virial coefficient.

Text : Statistical Mechanics and Properties of Matter by E. S. R.Gopal Pub. : McMilan Company of India Ltd.

(iii) Solid State Physics

Elastic constants and elastic waves. Analysis of elastic strains, Dilation, stress components. Elastic compliance and stiffness constants. Elastic energy density, elastic stiffness constants of cubic crystals, Bulk modulus and compressibility, Elastic waves in cubic crystals, waves in the [100] direction, waves in the [110] direction. Experimental determination of elastic constants. Third order elastic constants.

C. KITTEL CH : 4

Free electron Fermi gas I : Energy levels and density of orbitals in one dimension, Effect of temperature on the Fermi-Dirac distribution function. Free electron gas in three dimensions. Heat capacity of the electron gas experimental heat capacity of metals. Fermi liquid, Electrical conductivity and Ohm's law, experimental electrical resistivity of metals. Thermal conductivity of metals, ratio of thermal to electrical conductivity.

C. KITTEL CH : 7

Free electron Fermi gas II : Dielectric response of an electron gas, transverse optical modes in a plasma, transparency of alkali metals in the ultraviolet, Longitudinal optical modes in a plasma, Plasmons, electrostatic screening, Electron-Electron collisions, Motion in magnetic fields, Cyclotron frequency, static magneto conductivity, Hall effect.

C. KITTEL : Introduction to Solid State Physics : 4th Ed. John Wiley and Sons.

Magnetic fluids (A simple introductory information) 1.1 What are magnetic fluids ? 1.2 How are the magnetic fluids prepared ? 1.3. What are the factors to be kept in view while preparing ferromagnetic fluids ? 1.5. Applications of magnetic fluids.

Ref : Electronic materials by P. D. S. Verma Pub : Current Scientific Literature (available from PRASAR) 30, North Avenue, IIT Campus, New Delhi-110 016.

Super conductivity

Experimental survey. Occurence of superconductivity, Desstruction of superconductivity by magnetic fields, Meissner effect, Heat capacity, Energy gap, Microwave and infrared properties, Isotope effect.

C. KITTEL 4th Ed. CH : 12

PAPER VIII

(i) Electromagnetism (ii) Modern Optics (iii) Plasma Physics

ELECTROMAGNETISM

Special Techniques for calculating potentials.

3.1 Laplace's equation and uniqueness theorem

3.2 The method of images

3.3 Separation of variables

3.4 Multipole expansion

Ref : Introduction to electromdynamics by D. J. Griffiths Prentice Hall of India Pvt. Ltd.

Electromagnetic induction 5.7 Hysterisis 5.8 Maxwell's equations, 5.9 Decay of free charge, 5.10 Potentials of electromagnetic fields, 5.11 More about the Lorentz gauge condition, 5.12 Field energy and Field momentum. Electromagnetic waves 6.1. Plane waves in non conducting media, 6.2 polarization, 6.3 energy flux in a plane wave 6.4 Radiation pressure and momentum 6.5 Plane waves in conducting medium, 6.6 Skin effect.

Ref : Electromagnetics 2nd Ed. by B. B. Laud, Wiley Eastern Ltd.

MODERN OPTICS

6.4. Origin of refractive index. 15.10 Self focusing phenomenon. 15.11 spatial frequency filtering, Hollography 17.1. Introduction 17.2. Some applications, Lasers : 22.1 Introduction 22.2 sponteneous and stimulated emission, 22.3 population inversion, 22.4 resonator 22.5 He-Ne Laser.

Ref : Optics, by A. Ghatak, TMH,

Laser and non linear optics polarization P including higher order term in E and generation of harmonics.

FIBER OPTICS

Introduction, principles of light transmission in a fiber, the coherent bundle losses in fibers. Dispersion, light sources for fiber optics, photodetectors, connectors splices. Fiber optic communication system.

Ref : D. Reddy and J. Coolon 3rd Ed. of Electronic Communication.

PLASMA PHYSICS

Characteristics of plasma in magnetic field

3.1. Description of plasma as gas mixture

3.2. Properties of plasma in a magnetic field

3.3. Force on plasma in magnetic field

3.4. Current in magnelised plasma

3.5. Diffusion in a magnetic field

3.6. Collisions in fully ionised magnetoplasmas

3.7. Pinch effect

3.8. Oscillations and waves in the Plasma

3.9. MHD theory vs. two component or many component theory. Application of Boltzmann-Vlasov equation on plasma

4.1. Distribution function

4.2. Homogeneous, Inhomogeneous, Isotropic and anisotropic distribution funtions

4.3. Boltzmann equation

4.4. Fokker-Planck equation

4.5. Debye screening

4.6. Equilibrium distribution function and Boltzmann's H-theorem

4.7. Application of B-V equation to Longitudinal waves : Dispersion relations

4.8. Initial value problem : Landau damping

4.9. Cyclotron damping

4.10 Excitation, two-stream instability : Beam plasma instability, Pinch instability

4.11 Plasma sheath

4.12 Non linear effects

Ref : Elements of Plasma Physics by S. N. Goswami, New Central Book Agency (P) Ltd. Calcutta.

PAPER IX

(1) Nuclear Physics (2) Bio-Physics

(i) Nuclear Physics

Alpha Rays :

4.II. 1. Range of alpha particles, 4.II.2. Disintegration energy of the spontaneous α-Decay, 4.II.3. Alpha Decay Paradox-Barrier Penetration.

Beta Rays :

4.III.1. Introduction, 4.III.2. Continuous beta ray spectrum, difficulties encountered to understand it. 4.III.3. Pauli's Neutrino Hypothesis, 4.III.4. Fermi's theory of beta decay, 4.III.5. The detection of neutrino, 4.III.6. Parity non-conservation inbeta decay.

Gamma Rays :

4.IV.1. Introduction, 4.IV.2. Gamma-ray emission - selection rules, 4.IV.3. Internal conversion 4.IV.4. Nuclear Isomerism.

The liquid drop model of the nucleus :

5.1. Introduction 5.2. Binding energies of nuclei, plot of B/A against A. 5.3. Weizsacher's semi empirical mass formula 5.4. Mass parabolas : prediction of stability against Beta decay for members of an isobaric family, 5.5. Stability limits against spontaneous Fission, 5.6. Barrier penetration-Decay probabilities for spontaneous fission 5.7. nucleon emission.

Nuclear Energy :

6.1. Introduction 6.2. Neutron Induced Fission, 6.3. Asymmetrical fission-mass yield. 6.4. Emission of delayed Neutrons by fission fragments,6.5. energy released in the fission of U^{295} 6.6 Fission of lighter nuclei, 6.7. Fission chain reaction, 6.8. neutron cycle in a thermal nuclear reactor, 6.9. nuclear reactors.

Nuclear Physics in other areas of Physics :

9.1. Introduction, 9.2. The technique of NMR, 9.3. Some experiments with NMR, 9.4. The Mossbaur effect 9.5. some experiments using Mossbaur effect 9.6. Natural Fusion - energy production in stars, 9.7. possibility of controlled fusion.

Text : Nuclear Physics (An Introduction by S. B. Patel Wiley Eastern Limited.)

Elementrary Particles :

14.4. Leptons, 14.5. Hadrons, 14.6. Elementary particle quantum numbers, 14.7. Isospin 14.8. Symmetries and conservation principles, 14.9. Quarks, 14.10. fundamental interactions, 14.11 History of universe.

Text : Concept of Modern Physics 4th Ed. by A. Beiser McGraw Hill International Edition.

What is Biophysics ?

1. Plant and Animal cells, eucosiotic, proceriotic cells, compostion of a cell in terms of water, protein, phopholipid, lipid etc. Function of cells membrance, cytoplasm, nucleus, Mitochondria, Microsomes and other cell organelles. Biological molecules, nuclei acids, ATP structure and function in relation to bond formation, Genetic code, symmetry, revision of DNA structure Protein synthesis transcription, transition etc. interactions, molecular recognition.

2. Neutrophysics : Neutron anatomy; cell, dendrift, axon, background of neutron physiology. Physical and chemical background of membrance potential. Nernst equation; resting potential, ionic pumps, pores of different ionic species, action potential. Voltage clamp technique; conduction changes and Hodgkin-Huxley analysis. Cable equation; propagation of action potential, compound action potential.

Computers : Complete chapters 4, 5 and 6 of Programming in ANSI C 2nd Ed. by E. Balaguruswamy.

PAPER X

General amplifier characteristics :

Introduction, concept of amplification, amplifier notations, current gain, voltage gain, power gain, amplifier input resistance, amplifier output resistance, maximum power transfer, conversion efficiency, classes of amplifier operation, harmonic distortion, three point method of calculating harmonic distortion, five point method of calculating harmonic distortion, oscilloscope display of an amplifier dynamic transfer curve, measurement of harmonic distortion, other types of amplifier distortion, decibels, other equations for decibel computation, zero dB reference level, use of voltmeter as dB indicator, voltmeter range correction factor, impedance correction factor, frequency response curves, amplifier bandwidth, phase relationship in amplifier square wave testing.

Book recommended : Electronic Devices and circuits by A. Mottershead Art. Nos. 7.1 to 7.16 and 8.1 to 8.8, 8.10, 8.11.

Low frequency response of a transistor amplifier :

Effect of an emitter by pass capacitor on low frequency response, effect of coupling capacitor on low frequency response, cascading of CE stages, mid frequency gains, low frequency response of cascaded stages amplifier, low frequency response to a square wave, transformer coupled transistor amplifier, low frequency response of TC amplifier, step response of a TC amplifier.

Book recommended : Electronic Devices and circuits by A. Mottershead Art. Nos. 15.1 to 15.8

High frequency response of a transistor amplifier :

High frequency model for a CE amplifier, approximate CE high frequency model with a resistive load, CE short circuit current gain, high frequency current gain with a resistive load, high frequency response of cascaded CE stages, amplifier high frequency response to a square wave high frequency response of a transformer coupled amplifier.

Book recommended : Electronic Devices and circuits by A. Mottershead Art. Nos. 16.1 to 16.7

Negative Feedback in transistor amplifier :

General theory of feedback, reasons for negative feedback, loop gain, types of negative feedback in transistor circuits, Darlington connection, biasing the Darlington amplifier.

Book recommended : Electronic Devices and circuits by A. Mottershead Art. Nos. 17.1 to 17.6

Transistor Oscillators :

Introduction, Effect of positive feedback, requirements for oscillations, LC oscillators, (Colpit and Hearley oscillators with analysis)

Book recommended : Electronic Devices and circuits by A. Mottershead Art. Nos. 18.1 to 18.2

Hand Book of Electronics by Gupta and Kumar Art. Nos. 22.4, 22.5

Circuit analysis and design :

Boolean laws and theorems, sum of products method, truth table to Karnaugh map, pairs, quads and octets, Karnaugh simplification, don't care conditions, product of sums method product of sums simplification, Exclusive OR gate.

Book recommended : Digital Principles and Applications by Malvino and Leach Art. Nos. 2.1 to 2.8, * 3.7.

Number systems and codes :

Hexa decimal numbers, The ASCII code, The Excess 3 code, The gray code.

Book recommended : Digital Principles and Applications by Malvino and Leach Art. Nos. 4.5 to 4.8

Arithmetic circuits :

Binary addition binary subtraction, unsigned binary number, sign magnitude numbers, 2 S compliment representation, 2' S compliment arithmetic building blocks the adder - subtructactor, binary multiplication and division, Digital comparator, decoder, demultiplexer, data selector, encorder.

Book recommended : Digital Principles and Applications by Malvino and Leach Art. Nos. 5.1 to 5.9

Network Transformations :

Principle of duality, reduction of complicated network conversion between T and π sections, the bridged-T network, lattice network, the reciprocity theorem the compensation theorem, driving point impedance; transfer impedance, parallel T network.

Book recommended : Networks, lines and field by J. D. Ryder Art. Nos. 1.3 to 1.7, 1.9, 1.12, 1.14, 1.17

Resonance :

Definition of Q, the factor of merit, series resonance, band width of the series resonant circuit, parallel resonance, conditions for maximum impedance, currents in anti resonant circuits, impedance variation with freqwuency universal resonance curves, bandwidth of antiresonant circuits.

Book recommended : Networks, lines and field by J. D. Ryder Art. Nos. 2.1 to 2.8

Regulated Power Supply :

Introduction, stabilization, limitations of zener diode regulator, Transistor series voltage regulator, transistor shunt voltage regulator, a series regular with two transistors, current regulator.

Book recommended : Integrated Electronics by Millman & Halkias

Electronic Devices and Circuit Theory by Robert Boylestad

Electronic Devices & Circuits by A. Mottershead Art. Nos. 28.2 to 28.4

Electronic Instruments :

Cathode ray oscilloscope : CRO, CRT, electrongun, deflecting plates, screen, methods of focusing, deflection systems, mathematical expresion for electrostatic deflection sensitivity, electromagnetic deflection system, magnetic deflection in CRT, Time base (without circuits), CRO Parts, operation of a typical ocilloscope control, uses of CRO.

Book recommended : Electronic & Radio Engineering by M. L. Gupta Art. Nos. 36.1 to 36.11, 36.17, 36.18, 36.20. Dhanpat Rai & Sons.

Multimeters : (Analog & Digital)

Book recommended : Basic Electronics by Bhargava and Kulshestra

Op. Amplifier : Differential amplifiers, principles of Op. Amp. transfer characteristics, off set parameters, differential gain, CMRR, Application of Op. Amp. as inverting and non-inverting amplifiers.

Some topics given below list are not there in UGC programme. Some topics are only at either special level or at the elective level. At present it is not possible to change the structure of papers immediately and hence we feel that our programme is, as far as the contents are conserned is well comparable to UGC

programme. Hence immediately we do not feel any need to make drastic modification. In our programme already we have the more number of topics. To mention a few.

Deffects in crystals (Solid State).

Small oscillation (in classical mechanics) :

1. Matrix method in optics
2. Lasers (at T.Y.B.Sc. and M.Sc. level)
3. Holography
4. Non linear dynamics
5. Fiber Optics
6. Orbital Mechanics
7. Some elements of Atmospheric Physics
8. Remote Sensing
9. General theory of Relativity and Cosmology
10. Group theory
11. Green's functions
12. Integral equations
13. Computer programming in C
14. Relativistic quantam mechanics
15. Theory of angular momentum
16. Elements of Field quantization
17. Cluster diagram in Statistical Mechanics
18. Optical properties of solids
19. OPW, APW method of Band strucure calculations
20. Elastic constants of solids
21. Tensor analysis
22. Theory of dispersion
23. Particle diff. Eqns. of Physics
24. A numaber of topics of plasma physics
25. Complete representation theory
26. Magnetic fluids
27. Techniques of calculating potentials
28. Solar Physics
29. Projectile motion in Resistive medium
30. Combination of SHM
31. D. C. Circuit
32. Production and Measurements of low pressures.

PRACTICALS

UNIT I

1. Acceleration due to gravity by Kater's pendulum (with movable and fixed knife edges).
2. Young's modulus by optical method.
3. e/k by power transistor.
4. To determine melting point of a substance by platinum resistance thermometer using Callender-Griffiths bridge.
5. Hall effect.
6. An optical method of determining dielectric constant, dipole moment and polarizability of a polar liquid using Hollow prism
7. To determine thermal conductivity of rubber in the form of tube
8. To study fall of temperature of a cooling body (using thermo couple).
9. Study of thermocouple.
10. Viscocity by Log decrement

UNIT II

1. Refractive index by total internal reflection using Gauss eye piece.
2. Fabry-Perot etalon. Determination of the thickness of air film and wavelength of light using spectrometer.
3. To determine thickness of transparent plate using Michelson interferrometer.
4. Edser-Butler plate. To calibrate the spectrometer.
5. Babinates compensator. To analyse elliptically polarized light.
6. Michelson interferometer. To determine the wavelength of monochromatic light.
7. Michelson interferometer. To determine "$d\lambda$".
8. Absorption spectrum of Iodine molecule.
9. I - V Characteristics of Solar Cell and to determine fill-factor and voltage-factor

UNIT III

1. Hysterisis by Magnetometer method.
2. Heaviside mutual inductance bridge.
3. Comparison of capacities, Method of mixture.

4. Determination of capacity of scherreing Bridge.
5. Self inductance of a coil by Rayleigh's method.
6. Mutual inductance by Ballastic galvanometer.
7. A. C. Circuit analysis by C.R.O. Measurement of frequency and phase difference.
8. Enkor ring using C.R.O.
9. Susceptibility of freromagnetic substance by quink's method (Magnetic fluid).
10. Calibration of Magnetic field.

UNIT IV

1. Hartley Oscillator. Measurement of frequency by C.R.O. (Transisterised).
2. Series and parallel resonance. To find the band width and Q value of a coil.
3. Common emitter amplifier with varation of load at fixed frequency.
4. Common emitter amplifier by varying frequency at fixed load resistance.
5. Colpit oscillator.
6. Series resonance.
7. Negative feedback amplifier using transistor.
8. To determine the charge on electron by Millikan's experiment.
9. Half adder and Full adder.
10. Characteristics of G.M. Tube.
11. Determination of dead time of G.M. tube.
12. Comparison of relative intensities of different sources using G.M. Tube.

SCOPE : PRACTICAL PHYSICS BY S. L. GUPTA AND V. KUMAR.
