

Revised Edition

Modern Physics

For B.Sc./M.Sc. Students as Per Syllabi of Different Indian Universities and also as Per UGC Model Curriculum



R. MURUGESHAN
Er. KIRUTHIGA SIVAPRASATH

S. CHAND



MODERN PHYSICS

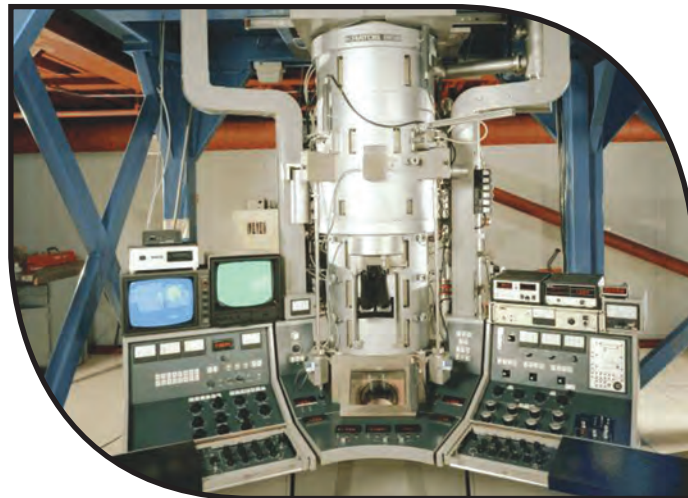
For B.Sc. / M.Sc. Students as per Syllabi of Different Indian Universities and also as per UGC Model Curriculum

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Preface to the Seventeenth Edition

The present **Multicolour Edition has been Revised** by taking into account the 2010 Question Papers of various Indian Universities. Multicolour pictures have been added to enhance the content value and to give the students an idea of what they will be dealing in reality, and to bridge the gap between the theory and practice.

We are thankful to the Management Team and the Editorial Department of S. Chand & Company Pvt. Ltd. for all help and support in the publication of this book.

Any errors, omissions and suggestions, for the improvement of this volume brought to our notice, will be thankfully acknowledged and incorporated in the next edition.

AUTHORS

Preface to the First Edition

The purpose of this book is to give an introductory account of the basic principles of atomic, nuclear and solid state physics. It is meant to serve as a textbook for the B.Sc. Physics students of Indian Universities. SI system of units has been used throughout the text. Great care has been taken in dealing with the subject with modern outlook. A large number of questions and problems have been given at the end of each chapter.

All available standard books on the subject have been freely consulted during the preparation of this book. I acknowledge gratefully my indebtedness to the authors and publishers of different books on the subject. I am grateful to my revered teachers Dr. S. Hariharan M.Sc., Ph.D. (Leeds), Prof. S.N. Neelakantan Nambisan B.Sc. (Hons.), Prof. P. Radhakrishna Menon M.A., Prof. P. Balakrishnan M.A., Prof. K. Padmanabha Sharma M.Sc., and others of Govt. Victoria College, Palghat, Kerala, who contributed to my education in Modern Physics.

I am extremely thankful to Prof. K. Ramamurthi M. Com., Secretary and Prof. K. Subrahmanyam M.A. Principal, of our College for their encouragement and help.

I wish to dedicate this book at the holy feet of Srimad Swami Chidbavanandaji, President of our college. To Swamiji, I owe more than words can describe for his lifelong devotion and guidance in unfolding my hidden potentialities and developing my personality. I can only hope that this book reflects something of his insistence on lucid and concise writing.

Lastly, I would like to thank my Publishers, M/s. S. Chand & Company Ltd.

I especially want to thank the Proprietor, Mr. S.L. Gupta and the Madras Branch Manager Mr. S. Venkatachalam.

Tiruvudakam

AUTHOR

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UGC MODEL CURRICULUM

B. Sc. Physics (General)

COURSE 7 : RELATIVITY, QUANTUM MECHANICS, ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

7.1 Relativity (15)

Reference systems, inertial frames, Galilean invariance and conservation laws, propagation of light, Michelson-Morley experiment; search for ether. (5)

Postulates of the special theory of relativity, Lorentz transformations, length contraction, time dilation, velocity addition theorem, variation of mass with velocity, mass-energy equivalence, particle with a zero rest mass. (10)

7.2 Quantum Mechanics (30)

Origin of the quantum theory: Failure of classical physics to explain the phenomena such as black-body spectrum, photoelectric effect, Ritz combination principle in spectra, stability of an atom. Planck's radiation law, Einstein's explanation of photoelectric effect, Bohr's quantization of angular momentum and its applications to hydrogen atom, limitations of Bohr's theory. (5)

Wave-particle duality and uncertainty principle: de Broglie's hypothesis for matter waves; the concept of wave and group velocities, evidence for diffraction and interference of 'particles', experimental demonstration of matter waves. (4)

Consequence of de Broglie's concepts; quantisation in hydrogen atom; energies of a particle in a box, wave packets, Heisenberg's uncertainty relation for p and x , its extension to energy and time. (3)

Consequence of the uncertainty relation: gamma ray microscope, diffraction at a slit, particle in a box, position of electron in a Bohr orbit. (3)

Quantum Mechanics: Schrodinger's equation. Postulatory basis of quantum mechanics; operators, expectation values, transition probabilities, applications to particle in a one-and three-dimensional boxes, harmonic oscillator, reflection at a step potential, transmission across a potential barrier. (7)

Hydrogen atom; natural occurrence of n , l and m quantum numbers, the related physical quantities, comparison with Bohr's theory. (4)

7.3 Atomic Physics (15)

Spectra of hydrogen, deuterium and alkali atoms, spectral terms, doublet fine structure, screening constants for alkali spectra for s , p , d , and f states, selection rules. (6)

Singlet and triplet fine structure in alkaline earth spectra, L-S and J-J couplings. (3)

Weak spectra: continuous X-ray spectrum and its dependence on voltage, Duane and Hunt's law, Characteristic X-rays. Moseley's law, doublet structure of X-ray spectra, X-ray absorption spectra. (3)

7.4 Molecular Physics (15)

Discrete set of electronic energies of molecules, quantisation of vibrational and rotational energies, determination of internuclear distance, pure rotational and rotation vibration spectra. Dissociation limit for the ground and other electronic states, transition rules for pure vibration and electronic vibration spectra. (7)

Raman effect, Stokes and anti-Stokes lines, complimentary character of Raman and infrared spectra, experimental arrangements for Raman spectroscopy.

Spectroscopic techniques: Sources of excitation, prism and grating spectrographs for visible, UV and IR, absorption spectroscopy, double beam instruments, different recording systems. (5)

7.5 Nuclear Physics (15)

Interaction of charged particles and neutrons with matter, working of nuclear detectors, G-M counter, proportional counter and scintillation counter, cloud chambers, spark chamber, emulsions. (5)

Structure of nuclei, basic properties (l , m , Q and binding energy), deuteron binding energy, p - p and n - p scattering and general concepts of nuclear forces. Beta decay, range of alpha particle, Geiger-Nuttall law, Gamow's explanation of beta decay, alpha decay and continuous and discrete spectra. (5)

Nuclear reactions, channels, compound nucleus, direct reaction (concepts). (3)

Shell model; liquid drop model, fission and fusion (concepts), energy production in stars by p - p and carbon cycles (concepts). (2)

COURSE 8: SOLID STATE PHYSICS, SOLID STATE DEVICES AND ELECTRONICS

8.1 Solid State Physics (30)

- Overview:** Crystalline and glassy forms, liquid crystals, glass transition. (2)
- Structure:** Crystal structure; periodicity, lattices and bases, fundamental translation vectors, unit cell, Wigner-Seitz cell, allowed rotations, lattice types, lattice planes, common crystal structures. (5)
- Laue's theory of X-ray diffraction, Bragg's law, Laue patterns. (2)
- Bonding:** Potential between a pair of atoms; Lennard-Jones potential, concept of cohesive energy, covalent, Van der Waals, ionic and metallic crystals. (3)
- Magnetism:** Atomic magnetic moment, magnetic susceptibility, Dia, para, and Ferromagnetism, Ferromagnetic domains, Hysteresis. (3)
- Thermal properties:** Lattice vibrations, simple harmonic oscillator, second order expansion of Lennard-Jones potential about the minimum, vibrations of one dimensional monatomic chain under harmonic and nearest neighbour interaction approximation, concept of phonons, density of modes (1-D). Debye model: lattice specific heat, low temperature limit, extension (conceptual) to 3-D. (8)
- Band structure:** Electrons in periodic potential; nearly free electron model (qualitative), energy bands, energy gap, metals, insulators, semiconductors. (3)
- Motion of electrons:** Free electrons, conduction electrons, electron collisions, mean free path, conductivity and Ohm's law. Density of states, Fermi energy, Fermi velocity, Fermi-Dirac distribution. (4)

8.2 Solid State Devices (15)

- Semiconductors:** Intrinsic semiconductors, electrons and holes, Fermi level. Temperature dependence of electron and hole concentrations. Doping: impurity states, *n* and *p* type semiconductors, conductivity, mobility, Hall effect. Hall coefficient. (7)
- Semiconductor devices:** Metal-semiconductor junction, p-n junction, majority and minority carriers, diode, Zener and tunnel diodes, light emitting diode, transistor, solar cell. (8)

8.3 Electronics (45)

- Power supply:** Diode as a circuit element, load line concept, rectification, ripple factor, zener diode, voltage stabilization, IC voltage regulation, characteristics of a transistor in CB, CE and CC mode, graphical analysis of the CE configuration, low frequency equivalent circuits, h-parameters, bias stability, thermal-runaway. (15)
- Field effect transistors:** JFET volt-ampere curves, biasing JFET, ac operation of JFET, source follower, Depletion and enhancement mode, MOSFET, biasing MOSFET, FET as variable voltage resistor, digital MOSFET circuits. (15)
- Small signal amplifiers:** General principles of operation, classification, distortion, RC coupled amplifier, gain, frequency response, input and output impedance, multistage amplifiers, transformer coupled amplifiers, Equivalent circuits at low, medium and high frequencies; emitter follower, low frequency common-source and common-drain amplifier, noise in electronic circuits. (15)

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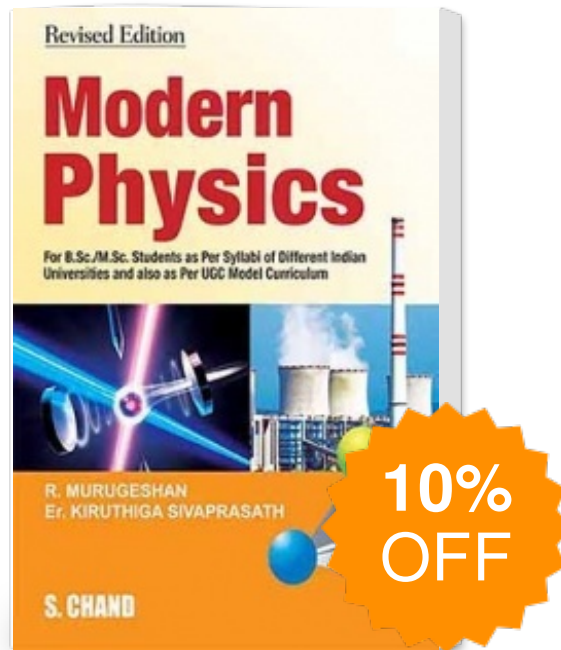
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