

PHYSICS

PART – II

TEXTBOOK FOR CLASS XII

© NCERT
not to be republished

© NCERT
not to be republished

PHYSICS

PART – II

TEXTBOOK FOR CLASS XII



12090



राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

12090 – PHYSICS PART-II

Textbook for Class XII

ISBN 81-7450-631-4 (Part I)

ISBN 81-7450-671-3 (Part II)

First Edition

March 2007 Chaitra 1928

Reprinted

December 2007, December 2008,
December 2009, January 2011,
January 2012, December 2012,
November 2013, December 2014,
December 2015, February 2017,
December 2017, February 2018,
February 2019, October 2019,
January 2021 and November 2021

Revised Edition

November 2022 Agrahayana 1944

PD 325T BS

© **National Council of Educational
Research and Training, 2007, 2022**

₹ 125.00

Printed on 80 GSM paper with NCERT
watermark

Published at the Publication Division by the
Secretary, National Council of Educational
Research and Training, Sri Aurobindo
Marg, New Delhi 110 016 and printed at
Royal Offset Printers, A-89/1, Naraina
Industrial Area, Phase-II, New Delhi 110 028

ALL RIGHTS RESERVED

- No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior permission of the publisher.
- This book is sold subject to the condition that it shall not, by way of trade, be lent, re-sold, hired out or otherwise disposed of without the publisher's consent, in any form of binding or cover other than that in which it is published.
- The correct price of this publication is the price printed on this page, Any revised price indicated by a rubber stamp or by a sticker or by any other means is incorrect and should be unacceptable.

OFFICES OF THE PUBLICATION DIVISION, NCERT

NCERT Campus
Sri Aurobindo Marg
New Delhi 110 016 Phone : 011-26562708

108, 100 Feet Road
Hosdakere Halli Extension
Banashankari III Stage
Bengaluru 560 085 Phone : 080-26725740

Navjivan Trust Building
P.O. Navjivan
Ahmedabad 380 014 Phone : 079-27541446

CWC Campus
Opp. Dhankal Bus Stop
Panihati
Kolkata 700 114 Phone : 033-25530454

CWC Complex
Maligaon
Guwahati 781 021 Phone : 0361-2674869

Publication Team

Head, Publication Division : Anup Kumar Rajput
Chief Production Officer : Arun Chitkara
Chief Business Manager : Vipin Dewan
Chief Editor (In charge) : Bijnan Sutar
Assistant Editor : R. N. Bhardwaj
Production Assistant : Sunil Kumar

Cover, Layout and Illustrations
Shweta Rao

FOREWORD

The National Curriculum Framework (NCF), 2005 recommends that children's life at school must be linked to their life outside the school. This principle marks a departure from the legacy of bookish learning which continues to shape our system and causes a gap between the school, home and community. The syllabi and textbooks developed on the basis of NCF signify an attempt to implement this basic idea. They also attempt to discourage rote learning and the maintenance of sharp boundaries between different subject areas. We hope these measures will take us significantly further in the direction of a child-centred system of education outlined in the National Policy on Education (NPE), 1986.

The success of this effort depends on the steps that school principals and teachers will take to encourage children to reflect on their own learning and to pursue imaginative activities and questions. We must recognise that, given space, time and freedom, children generate new knowledge by engaging with the information passed on to them by adults. Treating the prescribed textbook as the sole basis of examination is one of the key reasons why other resources and sites of learning are ignored. Inculcating creativity and initiative is possible if we perceive and treat children as participants in learning, not as receivers of a fixed body of knowledge.

These aims imply considerable change in school routines and mode of functioning. Flexibility in the daily time-table is as necessary as rigour in implementing the annual calendar so that the required number of teaching days are actually devoted to teaching. The methods used for teaching and evaluation will also determine how effective this textbook proves for making children's life at school a happy experience, rather than a source of stress or boredom. Syllabus designers have tried to address the problem of curricular burden by restructuring and reorienting knowledge at different stages with greater consideration for child psychology and the time available for teaching. The textbook attempts to enhance this endeavour by giving higher priority and space to opportunities for contemplation and wondering, discussion in small groups, and activities requiring hands-on experience.

The National Council of Educational Research and Training (NCERT) appreciates the hard work done by the textbook development committee responsible for this book. We wish to thank the Chairperson of the advisory group in science and mathematics, Professor J.V. Narlikar and the Chief Advisor for this book, Professor A.W. Joshi for guiding the work of this committee. Several teachers contributed to the development of this textbook; we are grateful to their principals for making this possible. We are indebted to the institutions and organisations which have generously permitted us to draw upon their resources, material and personnel. We are especially grateful to the members of the National Monitoring Committee, appointed by the Department of Secondary and Higher Education, Ministry of Human Resource Development under the Chairpersonship of Professor Mrinal Miri and Professor G.P. Deshpande, for their valuable time and contribution. As an organisation committed to systemic reform and continuous improvement in the quality of its products, NCERT welcomes comments and suggestions which will enable us to undertake further revision and refinement.

New Delhi
20 November 2006

Director
National Council of Educational
Research and Training

© NCERT
not to be republished

RATIONALISATION OF CONTENT IN THE TEXTBOOKS

In view of the COVID-19 pandemic, it is imperative to reduce content load on students. The National Education Policy 2020, also emphasises reducing the content load and providing opportunities for experiential learning with creative mindset. In this background, the NCERT has undertaken the exercise to rationalise the textbooks across all classes. Learning Outcomes already developed by the NCERT across classes have been taken into consideration in this exercise.

Contents of the textbooks have been rationalised in view of the following:

- Overlapping with similar content included in other subject areas in the same class
- Similar content included in the lower or higher class in the same subject
- Difficulty level
- Content, which is easily accessible to students without much interventions from teachers and can be learned by children through self-learning or peer-learning
- Content, which is irrelevant in the present context

This present edition, is a reformatted version after carrying out the changes given above.

© NCERT
not to be republished

PREFACE

It gives me pleasure to place this book in the hands of the students, teachers and the public at large (whose role cannot be overlooked). It is a natural sequel to the Class XI textbook which was brought out in 2006. This book is also a trimmed version of the textbooks which existed so far. The chapter on thermal and chemical effects of current has been cut out. This topic has also been dropped from the CBSE syllabus. Similarly, the chapter on communications has been substantially curtailed. It has been rewritten in an easily comprehensible form.

Although most other chapters have been based on the earlier versions, several parts and sections in them have been rewritten. The Development Team has been guided by the feedback received from innumerable teachers across the country.

In producing these books, Class XI as well as Class XII, there has been a basic change of emphasis. Both the books present physics to students without assuming that they would pursue this subject beyond the higher secondary level. This new view has been prompted by the various observations and suggestions made in the National Curriculum Framework (NCF), 2005. Similarly, in today's educational scenario where students can opt for various combinations of subjects, we cannot assume that a physics student is also studying mathematics. Therefore, physics has to be presented, so to say, in a stand-alone form.

As in Class XI textbook, some interesting box items have been inserted in many chapters. They are not meant for teaching or examinations. Their purpose is to catch the attention of the reader, to show some applications in daily life or in other areas of science and technology, to suggest a simple experiment, to show connection of concepts in different areas of physics, and in general, to break the monotony and enliven the book.

Features like Summary, Points to Ponder, Exercises and Additional Exercises at the end of each chapter, and Examples have been retained. Several concept-based Exercises have been transferred from end-of-chapter Exercises to Examples with Solutions in the text. It is hoped that this will make the concepts discussed in the chapter more comprehensible. Several new examples and exercises have been added. Students wishing to pursue physics further would find Points to Ponder and Additional Exercises very useful and thoughtful. To provide *resources beyond the textbook* and to encourage *eLearning*, each chapter has been provided with some relevant website addresses under the title *ePhysics*. These sites provide additional materials on specific topics and also provide learners the opportunities for interactive demonstrations/experiments.

The intricate concepts of physics must be understood, comprehended and appreciated. Students must learn to ask questions like 'why', 'how', 'how do we know it'. They will find almost always that the question 'why' has no answer within the domain of physics and science in general. But that itself is a learning experience, is it not? On the other hand, the question 'how' has been reasonably well answered by physicists in the case of most natural phenomena. In fact, with the understanding of how things happen, it has been possible to make use of many phenomena to create technological applications for the use of humans.

For example, consider statements in a book, like 'A negatively charged electron is attracted by the positively charged plate', or 'In this experiment, light (or electron) behaves like a wave'. You will realise that it is not possible to answer 'why'. This question belongs to the domain of philosophy or metaphysics. But we can answer 'how', we can find the force acting, we can find the wavelength of the photon (or electron), we can determine how things behave under different conditions, and we can develop instruments which will use these phenomena to our advantage.

It has been a pleasure to work for these books at the higher secondary level, along with a team of members. The Textbook Development Team, the Review Team and Editing Teams involved college and university teachers, teachers from Indian Institutes of Technology, scientists from national institutes and laboratories, as well as higher secondary teachers. The feedback and critical look provided by higher secondary teachers in the various teams are highly laudable. Most box items were generated by members of one or the other team, but three of them were generated by friends and well-wishers not part of any team. We are thankful to Dr P.N. Sen of Pune, Professor Roopmanjari Ghosh of Delhi and Dr Rajesh B Khaparde of Mumbai for allowing us to use their box items, respectively in Chapters 3, 4 (Part I) and 9 (Part II). We are very thankful to the members of the Review and Editing Workshops to discuss and refine the first draft of the textbook. We also express our gratitude to Prof. Krishna Kumar, Director, NCERT, for entrusting us with the task of presenting this textbook as a part of the national effort for improving science education. I also thank Prof. G. Ravindra, Joint Director, NCERT, for his help from time-to-time. Prof. Hukum Singh, Head, Department of Education in Science and Mathematics, NCERT, was always willing to help us in our endeavour in every possible way.

We welcome suggestions and comments from our valued users, especially students and teachers. We wish our young readers a happy journey into the exciting realm of physics.

A. W. JOSHI
Chief Advisor
Textbook Development Committee

TEXTBOOK DEVELOPMENT COMMITTEE

CHAIRPERSON, ADVISORY COMMITTEE FOR TEXTBOOKS IN SCIENCE AND MATHEMATICS

J.V. Narlikar, *Emeritus Professor*, Inter-University Centre for Astronomy and Astrophysics (IUCAA), Ganeshkhind, Pune University Campus, Pune

CHIEF ADVISOR

A.W. Joshi, *Honorary Visiting Scientist*, National Centre for Radio Astrophysics (NCRA), Pune University Campus, Pune (Formerly *Professor* at Department of Physics, University of Pune)

MEMBERS

A.K. Ghatak, *Emeritus Professor*, Department of Physics, Indian Institute of Technology, New Delhi

Alika Khare, *Professor*, Department of Physics, Indian Institute of Technology, Guwahati

Anjali Kshirsagar, *Reader*, Department of Physics, University of Pune, Pune

Anuradha Mathur, *PGT*, Modern School, Vasant Vihar, New Delhi

Atul Mody, *Lecturer (S.G.)*, VES College of Arts, Science and Commerce, Mumbai

B.K. Sharma, *Professor*, DESM, NCERT, New Delhi

Chitra Goel, *PGT*, Rajkiya Pratibha Vikas Vidyalaya, Tyagraj Nagar, New Delhi

Gagan Gupta, *Reader*, DESM, NCERT, New Delhi

H.C. Pradhan, *Professor*, Homi Bhabha Centre of Science Education (TIFR), Mumbai

N. Panchapakesan, *Professor (Retd.)*, Department of Physics and Astrophysics, University of Delhi, Delhi

R. Joshi, *Lecturer (S.G.)*, DESM, NCERT, New Delhi

S.K. Dash, *Reader*, DESM, NCERT, New Delhi

S. Rai Choudhary, *Professor*, Department of Physics and Astrophysics, University of Delhi, Delhi

S.K. Upadhyay, *PGT*, Jawahar Navodaya Vidyalaya, Muzaffar Nagar

S.N. Prabhakara, *PGT*, DM School, Regional Institute of Education (NCERT), Mysore

V.H. Raybagkar, *Reader*, Nowrosjee Wadia College, Pune

Vishwajeet Kulkarni, *Teacher (Grade I)*, Higher Secondary Section, Smt. Parvatibai Chowgule College, Margao, Goa

MEMBER-COORDINATOR

V.P. Srivastava, *Reader*, DESM, NCERT, New Delhi

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a ¹**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the ²[unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)

ACKNOWLEDGEMENTS

The National Council of Educational Research and Training acknowledges the valuable contribution of the individuals and organisations involved in the development of Physics Textbook for Class XII. The Council also acknowledges the valuable contribution of the following academics for reviewing and refining the manuscripts of this book:

Anu Venugopalan, *Lecturer*, School of Basic and Applied Sciences, GGSIP University, Delhi; A.K. Das, *PGT*, St. Xavier's Senior Secondary School, Delhi; Bharati Kukkal, *PGT*, Kendriya Vidyalaya, Pushp Vihar, New Delhi; D.A. Desai, *Lecturer (Retd.)*, Ruparel College, Mumbai; Devendra Kumar, *PGT*, Rajkiya Pratibha Vikas Vidyalaya, Yamuna Vihar, Delhi; I.K. Gogia, *PGT*, Kendriya Vidyalaya, Gole Market, New Delhi; K.C. Sharma, *Reader*, Regional Institute of Education (NCERT), Ajmer; M.K. Nandy, *Associate Professor*, Department of Physics, Indian Institute of Technology, Guwahati; M.N. Bapat, *Reader*, Regional Institute of Education (NCERT), Mysore; R. Bhattacharjee, *Asstt. Professor*, Department of Electronics and Communication Engineering, Indian Institute of Technology, Guwahati; R.S. Das, *Vice-Principal (Retd.)*, Balwant Ray Mehta Senior Secondary School, Lajpat Nagar, New Delhi; Sangeeta D. Gadre, *Reader*, Kirori Mal College, Delhi; Suresh Kumar, *PGT*, Delhi Public School, Dwarka, New Delhi; Sushma Jaireth, *Reader*, Department of Women's Studies, NCERT, New Delhi; Shyama Rath, *Reader*, Department of Physics and Astrophysics, University of Delhi, Delhi; Yashu Kumar, *PGT*, Kulachi Hans Raj Model School, Ashok Vihar, Delhi.

The Council also gratefully acknowledges the valuable contribution of the following academics for the editing and finalisation of this book: B.B. Tripathi, *Professor (Retd.)*, Department of Physics, Indian Institute of Technology, New Delhi; Dipan K. Ghosh, *Professor*, Department of Physics, Indian Institute of Technology, Mumbai; Dipanjan Mitra, *Scientist*, National Centre for Radio Astrophysics (TIFR), Pune; G.K. Mehta, *Raja Ramanna Fellow*, Inter-University Accelerator Centre, New Delhi; G.S. Visweswaran, *Professor*, Department of Electrical Engineering, Indian Institute of Technology, New Delhi; H.C. Kandpal, *Head*, Optical Radiation Standards, National Physical Laboratory, New Delhi; H.S. Mani, *Raja Ramanna Fellow*, Institute of Mathematical Sciences, Chennai; K. Thyagarajan, *Professor*, Department of Physics, Indian Institute of Technology, New Delhi; P.C. Vinod Kumar, *Professor*, Department of Physics, Sardar Patel University, Vallabh Vidyanagar, Gujarat; S. Annapoorni, *Professor*, Department of Physics and Astrophysics, University of Delhi, Delhi; S.C. Dutta Roy, *Emeritus Professor*, Department of Electrical Engineering, Indian Institute of Technology, New Delhi; S.D. Joglekar, *Professor*, Department of Physics, Indian Institute of Technology, Kanpur; V. Sundara Raja, *Professor*, Sri Venkateswara University, Tirupati.

The Council also acknowledges the valuable contributions of the following academics for refining the text in 2017: A.K. Srivastava, *Assistant Professor*, DESM, NCERT, New Delhi; Arnab Sen, *Assistant Professor*, NERIE, Shillong; L.S. Chauhan, *Assistant Professor*, RIE, Bhopal; O.N. Awasthi, *Professor (Retd.)*, RIE, Bhopal; Rachna Garg, *Professor*, DESM, NCERT, New Delhi; Raman Namboodiri, *Assistant Professor*, RIE, Mysuru; R.R. Koireng, *Assistant Professor*, DCS, NCERT, New Delhi; Shashi Prabha, *Professor*, DESM, NCERT, New Delhi; and S.V. Sharma, *Professor*, RIE, Ajmer.

Special thanks are due to Hukum Singh, *Professor and Head*, DESM, NCERT for his support.

The Council also acknowledges the support provided by the APC office and the administrative staff of the DESM; Deepak Kapoor, *Incharge*, Computer Station; Inder Kumar, *DTP Operator*; Mohd. Qamar Tabrez and Hari Darshan Lodhi *Copy Editor*; Rishi Pal Singh, *Sr. Proof Reader*, NCERT and Ashima Srivastava, *Proof Reader* in shaping this book.

The contributions of the Publication Department in bringing out this book are also duly acknowledged.

Contents of Physics Part I Class XII

CHAPTER ONE ELECTRIC CHARGES AND FIELDS	1
CHAPTER TWO ELECTROSTATIC POTENTIAL AND CAPACITANCE	45
CHAPTER THREE CURRENT ELECTRICITY	81
CHAPTER FOUR MOVING CHARGES AND MAGNETISM	107
CHAPTER FIVE MAGNETISM AND MATTER	136
CHAPTER SIX ELECTROMAGNETIC INDUCTION	154
CHAPTER SEVEN ALTERNATING CURRENT	177
CHAPTER EIGHT ELECTROMAGNETIC WAVES	201
ANSWERS	217

CONTENTS

FOREWORD	<i>v</i>
RATIONALISATION OF CONTENT IN THE TEXTBOOK	<i>vii</i>
PREFACE	<i>ix</i>
CHAPTER NINE	
RAY OPTICS AND OPTICAL INSTRUMENTS	
9.1 Introduction	221
9.2 Reflection of Light by Spherical Mirrors	222
9.3 Refraction	228
9.4 Total Internal Reflection	229
9.5 Refraction at Spherical Surfaces and by Lenses	232
9.6 Refraction through a Prism	239
9.7 Optical Instruments	240
CHAPTER TEN	
WAVE OPTICS	
10.1 Introduction	255
10.2 Huygens Principle	257
10.3 Refraction and Reflection of Plane Waves using Huygens Principle	258
10.4 Coherent and Incoherent Addition of Waves	262
10.5 Interference of Light Waves and Young's Experiment	265
10.6 Diffraction	266
10.7 Polarisation	269
CHAPTER ELEVEN	
DUAL NATURE OF RADIATION AND MATTER	
11.1 Introduction	274
11.2 Electron Emission	275

11.3	Photoelectric Effect	276
11.4	Experimental Study of Photoelectric Effect	277
11.5	Photoelectric Effect and Wave Theory of Light	280
11.6	Einstein's Photoelectric Equation: Energy Quantum of Radiation	281
11.7	Particle Nature of Light: The Photon	283
11.8	Wave Nature of Matter	284

CHAPTER TWELVE

ATOMS

12.1	Introduction	290
12.2	Alpha-particle Scattering and Rutherford's Nuclear Model of Atom	291
12.3	Atomic Spectra	296
12.4	Bohr Model of the Hydrogen Atom	297
12.5	The Line Spectra of the Hydrogen Atom	300
12.6	DE Broglie's Explanation of Bohr's Second Postulate of Quantisation	301

CHAPTER THIRTEEN

NUCLEI

13.1	Introduction	306
13.2	Atomic Masses and Composition of Nucleus	306
13.3	Size of the Nucleus	309
13.4	Mass-Energy and Nuclear Binding Energy	310
13.5	Nuclear Force	313
13.6	Radioactivity	314
13.7	Nuclear Energy	314

CHAPTER FOURTEEN

SEMICONDUCTOR ELECTRONICS: MATERIALS, DEVICES AND SIMPLE CIRCUITS

14.1	Introduction	323
14.2	Classification of Metals, Conductors and Semiconductors	324
14.3	Intrinsic Semiconductor	327
14.4	Extrinsic Semiconductor	329

14.5	p-n Junction	333
14.6	Semiconductor Diode	334
14.7	Application of Junction Diode as a Rectifier	338
APPENDICES		344
ANSWERS		346
BIBLIOGRAPHY		353

© NCERT
not to be republished

COVER DESIGN

(Adapted from <http://nobelprize.org> and
the Nobel Prize in Physics 2006)

Different stages in the evolution of
the universe.

BACK COVER

(Adapted from <http://www.iter.org> and
<http://www.dae.gov.in>)

Cut away view of *International Thermonuclear Experimental Reactor* (ITER) device. The man in the bottom shows the scale.

ITER is a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power.

India is one of the seven full partners in the project, the others being the European Union (represented by EURATOM), Japan, the People's Republic of China, the Republic of Korea, the Russian Federation and the USA. ITER will be constructed in Europe, at Cadarache in the South of France and will provide 500 MW of fusion power.

Fusion is the energy source of the sun and the stars. On earth, fusion research is aimed at demonstrating that this energy source can be used to produce electricity in a safe and environmentally benign way, with abundant fuel resources, to meet the needs of a growing world population.

For details of India's role, see *Nuclear India*, Vol. 39, No. 11-12/ May-June 2006, issue available at Department of Atomic Energy (DAE) website mentioned above.
