

# PHYSICS

PART – II

TEXTBOOK FOR CLASS XII

© NCERT  
not to be republished

© NCERT  
not to be republished

# PHYSICS

PART – II

TEXTBOOK FOR CLASS XII

© NCERT  
not to be republished



12090



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

2021–22

**First Edition**

March 2007 Chaitra 1928

**Reprinted**

December 2007 Agrahayana 1929

December 2008 Pausha 1930

December 2009 Pausha 1931

January 2011 Pausha 1932

January 2012 Magha 1933

December 2012 Agrahayana 1934

November 2013 Kartika 1935

December 2014 Pausha 1936

December 2015 Agrahayana 1937

February 2017 Magha 1938

December 2017 Pausha 1939

February 2018 Magha 1939

February 2019 Magha 1940

October 2019 Ashwina 1941

January 2021 Pausha 1942

**PD 64T RSP**

© National Council of Educational  
Research and Training, 2007

₹ .....

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 ...

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

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

**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 Editor : Shweta Uppal

Chief Production Officer : Arun Chitkara

Chief Business Manager (In charge) : Vipin Dewan

Assistant Editor : R. N. Bhardwaj

Production Assistant : .....

**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

## 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 <sup>1</sup>**[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 <sup>2</sup>[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**

<b>CHAPTER ONE</b>	
<b>ELECTRIC CHARGES AND FIELDS</b>	<b>1</b>
<b>CHAPTER TWO</b>	
<b>ELECTROSTATIC POTENTIAL AND CAPACITANCE</b>	<b>51</b>
<b>CHAPTER THREE</b>	
<b>CURRENT ELECTRICITY</b>	<b>93</b>
<b>CHAPTER FOUR</b>	
<b>MOVING CHARGES AND MAGNETISM</b>	<b>132</b>
<b>CHAPTER FIVE</b>	
<b>MAGNETISM AND MATTER</b>	<b>173</b>
<b>CHAPTER SIX</b>	
<b>ELECTROMAGNETIC INDUCTION</b>	<b>204</b>
<b>CHAPTER SEVEN</b>	
<b>ALTERNATING CURRENT</b>	<b>233</b>
<b>CHAPTER EIGHT</b>	
<b>ELECTROMAGNETIC WAVES</b>	<b>269</b>
<b>ANSWERS</b>	<b>288</b>

## CONTENTS

<b>FOREWORD</b>	<i>v</i>
-----------------	----------

<b>PREFACE</b>	<i>vii</i>
----------------	------------

### CHAPTER NINE

#### RAY OPTICS AND OPTICAL INSTRUMENTS

<b>9.1</b>	Introduction	309
<b>9.2</b>	Reflection of Light by Spherical Mirrors	310
<b>9.3</b>	Refraction	316
<b>9.4</b>	Total Internal Reflection	319
<b>9.5</b>	Refraction at Spherical Surfaces and by Lenses	323
<b>9.6</b>	Refraction through a Prism	330
<b>9.7</b>	Some Natural Phenomena due to Sunlight	332
<b>9.8</b>	Optical Instruments	335

### CHAPTER TEN

#### WAVE OPTICS

<b>10.1</b>	Introduction	351
<b>10.2</b>	Huygens Principle	353
<b>10.3</b>	Refraction and Reflection of Plane Waves using Huygens Principle	355
<b>10.4</b>	Coherent and Incoherent Addition of Waves	360
<b>10.5</b>	Interference of Light Waves and Young's Experiment	362
<b>10.6</b>	Diffraction	367
<b>10.7</b>	Polarisation	376

### CHAPTER ELEVEN

#### DUAL NATURE OF RADIATION AND MATTER

<b>11.1</b>	Introduction	386
<b>11.2</b>	Electron Emission	387
<b>11.3</b>	Photoelectric Effect	388
<b>11.4</b>	Experimental Study of Photoelectric Effect	389

<b>11.5</b>	Photoelectric Effect and Wave Theory of Light	393
<b>11.6</b>	Einstein's Photoelectric Equation: Energy Quantum of Radiation	393
<b>11.7</b>	Particle Nature of Light: The Photon	395
<b>11.8</b>	Wave Nature of Matter	398
<b>11.9</b>	Davisson and Germer Experiment	403

## **CHAPTER TWELVE**

### **ATOMS**

<b>12.1</b>	Introduction	414
<b>12.2</b>	Alpha-particle Scattering and Rutherford's Nuclear Model of Atom	415
<b>12.3</b>	Atomic Spectra	420
<b>12.4</b>	Bohr Model of the Hydrogen Atom	422
<b>12.5</b>	The Line Spectra of the Hydrogen Atom	428
<b>12.6</b>	DE Broglie's Explanation of Bohr's Second Postulate of Quantisation	430

## **CHAPTER THIRTEEN**

### **NUCLEI**

<b>13.1</b>	Introduction	438
<b>13.2</b>	Atomic Masses and Composition of Nucleus	438
<b>13.3</b>	Size of the Nucleus	441
<b>13.4</b>	Mass-Energy and Nuclear Binding Energy	442
<b>13.5</b>	Nuclear Force	445
<b>13.6</b>	Radioactivity	446
<b>13.7</b>	Nuclear Energy	451

## **CHAPTER FOURTEEN**

### **SEMICONDUCTOR ELECTRONICS: MATERIALS, DEVICES AND SIMPLE CIRCUITS**

<b>14.1</b>	Introduction	467
<b>14.2</b>	Classification of Metals, Conductors and Semiconductors	468
<b>14.3</b>	Intrinsic Semiconductor	472
<b>14.4</b>	Extrinsic Semiconductor	474
<b>14.5</b>	p-n Junction	478
<b>14.6</b>	Semiconductor Diode	479
<b>14.7</b>	Application of Junction Diode as a Rectifier	483

<b>14.8</b>	Special Purpose p-n Junction Diodes	485
<b>14.9</b>	Digital Electronics and Logic Gates	490
<b>APPENDICES</b>		500
<b>ANSWERS</b>		502
<b>BIBLIOGRAPHY</b>		518
<b>INDEX</b>		520

© 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.

---