Revised Edition

A Textbook of Engineering Physics

For the Students of B.E., B.Tech., B.Arch. and B.Sc. (Engg.)

Dr. M.N. AVADHANULU
Dr. P.G. KSHIRSAGAR

S. CHAND

A TEXTBOOK OF
ENGINEERING PHYSICS

[For the Students of B.E., B.Tech., B.Arch., B.Sc., (Engg.)]

Dr. M.N. Avadhanulu

M.Sc.,Ph.D.

Ex-Principal, Om College of Engineering of Wardha
Former Professor and Head, Department of Physics
Kavikulguru Institute of Technology & Science
Ramtek-441 106, Dist. Nagpur (M.S.)

and

Dr. P.G. Kshirsagar

M.Sc., Ph.D.

Formerly Head of the Department of Applied Physics,
Visvesvaraya National Institute of Technology
NAGPUR

[Revised Edition]

S. CHAND & COMPANY PVT. LTD.

(AN ISO 9001 : 2008 COMPANY)

RAM NAGAR, NEW DELHI-110 055

S. CHAND & COMPANY PVT. LTD.

(An ISO 9001 : 2008 Company)

Head Office: 7361, RAM NAGAR, NEW DELHI - 110 055

Phone: 23672080-81-82, 9899107446, 9911310888 Fax: 91-11-23677446

Shop at: **schandgroup.com;** e-mail: **info@schandgroup.com**

Branches :

AHMEDABAD : 1st Floor, Heritage, Near Gujarat Vidhyapeeth, Ashram Road, **Ahmedabad** - 380 014, Ph: 27541965, 27542369, ahmedabad@schandgroup.com

BENGALURU : No. 6, Ahuja Chambers, 1st Cross, Kumara Krupa Road, **Bengaluru** - 560 001, Ph: 22268048, 22354008, bangalore@schandgroup.com

BHOPAL : Bajaj Tower, Plot No. 2&3, Lala Lajpat Rai Colony, Raisen Road, **Bhopal** - 462 011, Ph: 4274723, 4209587. bhopal@schandgroup.com

CHANDIGARH : S.C.O. 2419-20, First Floor, Sector - 22-C (Near Aroma Hotel), **Chandigarh** -160 022, Ph: 2725443, 2725446, chandigarh@schandgroup.com

CHENNAI : No.1, Whites Road, Opposite Express Avenue, Royapettah, **Chennai** - 600014 Ph. 28410027, 28410058, chennai@schandgroup.com

COIMBATORE : 1790, Trichy Road, LGB Colony, Ramanathapuram, **Coimbatore** -6410045, Ph: 2323620, 4217136 coimbatore@schandgroup.com **(Marketing Office)**

CUTTACK : 1st Floor, Bhartia Tower, Badambadi, **Cuttack** - 753 009, Ph: 2332580; 2332581, cuttack@schandgroup.com

DEHRADUN : 1st Floor, 20, New Road, Near Dwarka Store, **Dehradun** - 248 001, Ph: 2711101, 2710861, dehradun@schandgroup.com

GUWAHATI : Dilip Commercial (Ist floor), M.N. Road, Pan Bazar, **Guwahati** - 781 001, Ph: 2738811, 2735640 guwahati@schandgroup.com

HYDERABAD : Padma Plaza, H.No. 3-4-630, Opp. Ratna College, Narayanaguda, **Hyderabad** - 500 029, Ph: 27550194, 27550195, hyderabad@schandgroup.com

JAIPUR : 1st Floor, Nand Plaza, Hawa Sadak, Ajmer Road, **Jaipur** - 302 006, Ph: 2219175, 2219176, jaipur@schandgroup.com

JALANDHAR : Mai Hiran Gate, **Jalandhar** - 144 008, Ph: 2401630, 5000630, jalandhar@schandgroup.com

KOCHI : Kachapilly Square, Mullassery Canal Road, Ernakulam, **Kochi** - 682 011, Ph: 2378740, 2378207-08, cochin@schandgroup.com

KOLKATA : 285/J, Bipin Bihari Ganguli Street, **Kolkata** - 700 012, Ph: 22367459, 22373914, kolkata@schandgroup.com

LUCKNOW : Mahabeer Market, 25 Gwynne Road, Aminabad, **Lucknow** - 226 018, Ph: 4076971, 4026791, 4065646, 4027188, lucknow@schandgroup.com

MUMBAI : Blackie House, IInd Floor, 103/5, Walchand Hirachand Marg, Opp. G.P.O., **Mumbai** - 400 001, Ph: 22690881, 22610885, mumbai@schandgroup.com

NAGPUR : Karnal Bagh, Near Model Mill Chowk**, Nagpur** - 440 032, Ph: 2720523, 2777666 nagpur@schandgroup.com

PATNA : 104, Citicentre Ashok, Mahima Palace , Govind Mitra Road, **Patna** - 800 004, Ph: 2300489, 2302100, patna@schandgroup.com

PUNE : 291, Flat No.-16, Ganesh Gayatri Complex, IInd Floor, Somwarpeth, Near Jain Mandir, **Pune** - 411 011, Ph: 64017298, pune@schandgroup.com **(Marketing Office)**

RAIPUR : Kailash Residency, Plot No. 4B, Bottle House Road, Shankar Nagar, **Raipur -** 492 007, Ph: 2443142,Mb. : 09981200834, raipur@schandgroup.com **(Marketing Office)**

RANCHI : Flat No. 104, Sri Draupadi Smriti Apartments, (Near of Jaipal Singh Stadium) Neel Ratan Street, Upper Bazar, **Ranchi** - 834 001, Ph: 2208761, ranchi@schandgroup.com **(Marketing Office)**

SILIGURI : 122, Raja Ram Mohan Roy Road, East Vivekanandapally, P.O., Siliguri, **Siliguri-**734001, Dist., Jalpaiguri, (W.B.) Ph. 0353-2520750 **(Marketing Office)** siliguri@schandgroup.com

VISAKHAPATNAM : No. 49-54-15/53/8, Plot No. 7, 1st Floor, Opp. Radhakrishna Towers, Seethammadhara North Extn., **Visakhapatnam** - 530 013, Ph-2782609 (M) 09440100555, visakhapatnam@schandgroup.com **(Marketing Office)**

First Edition 1992

Subsequent Editions and Reprints 1993, 94, 95, 98, 2000, 2001 (Twice), 2003, 2004, 2005, 2006 (Twice), 2007, 2008, 2009 (Twice), 2010, 2011 (Twice); 2012

Thoroughly Revised Edition 2014

ISBN : 81-219-0817-5 **Code : 10B 131**

PRINTED IN INDIA

By Rajendra Ravindra Printers Pvt. Ltd., 7361, Ram Nagar, New Delhi -110 055
and published by S. Chand & Company Pvt. Ltd., 7361, Ram Nagar, New Delhi -110 055.

Preface to the Revised Edition

A Textbook of Engineering Physics is originally designed to serve as a textbook as well as reference book for two semester course in Engineering Physics. The book is written with two distinct objectives: First to provide a single source of information and the second to present the principles of Physics as relevant to the B.E./B.Tech. students in an easy-to-understand style. In this edition, a new chapter number 40 namely "Geometrical Optics" has been added to make the book still more useful to the students. The requirements of the students are given priority and the material is moulded in a more student-friendly style. However, the spirit of Physics is not sacrificed at any stage and the expectations of teachers are held high at every step. It is generally felt that Physics is one more body of facts thrust on engineering students who are already burdened with a heavy syllabus and evolved through the efforts of rational thinkers who have been interested to know; why, what and how of natural phenomena.

Engineering has emerged as the application of their understanding for the benefit of human society at large. Thus Physics is the foundation on which stands the elaborate structure of technology. The main purpose of teaching Physics to Engineering undergraduates is to acquaint the budding engineers with the thread of development and the urge that underlies the presentation of the material in this book, so that they can apply this knowledge beneficially in their later pursuits.

The authors sincerely hope that this book will assist the students in learning the principles of Physics more effectively.

Enough care is taken to eliminate printing mistakes. However, some mistakes might have crept in inadvertently. The authors appeal to the readers to point out such left-out mistakes.

The authors are also highly indebted to the teachers in various engineering institutions who have been extending unstinted support to this book.

M.N.AVADHANULU
mna2005@rediffmail.com

Preface to the Ninth Revised Edition

"A Textbook of Engineering Physics" is written with two distinct objectives : to provide a single source of information for engineering undergraduates of different specializations and provide them a solid base in physics. Successive editions of the book incorporated topics as required by students pursuing their studies in various universities. In this new edition the contents are fine-tuned, modernized and updated at various stages.

Physics is not an isolated body of theories which merely serve vocational usefulness. What has been achieved in physics has sooner or later made tremendous impact on the technological growth of our society. To become active participants in the technological revolution, one has to necessarily acquaint himself with the methods of science. Mechanical memorizing of certain definitions and derivations does not belong to the method of science and as such is of little value to the student. The main purpose of teaching physics to engineering undergraduates is to equip them with an understanding of the "scientific method", so that they may use the training beneficially in their higher pursuits. An earnest attempt is made in this direction right from the first edition of this book by blending careful presentation of fundamental concepts and methods of physics.

This edition retains the original theme of emphasis on concepts with less mathematical formalism. The practical applications are discussed at each stage. The question bank given at the end of each chapter is updated. At a number of places, points for refinement are noticed and those have been incorporated. We have gladly received and carefully considered suggestions from professors and students who have used earlier editions. Further suggestions for improvement of the quality and quantity of the content are most welcome.

M.N.AVADHANULU
mna2005@rediffmail.com

Acknowledgement

The authors offer their special thanks to Smt. Nirmala Gupta, Chairperson & Managing Director, Shri Amit Gupta, C.E.O., Shri Naveen Joshi, Executive vice-president (Publishing), Shri Bhagirath Kaushik, Vice president (Sales and Marketing), S.Chand & Company Ltd. and Shri Vijay, Branch Manager, Nagpur and their dedicated team for all their efforts in bringing out this book nicely and in time.

M.N.AVADHANULU
mna2005@rediffmail.com

Dedicated to

My Mother,

Maternal Uncles

Shri Mullapudi Suryanarayana,

Dr.Mullapudi Subba Rao and

Shri Mullapudi Satyanarayana,

and to

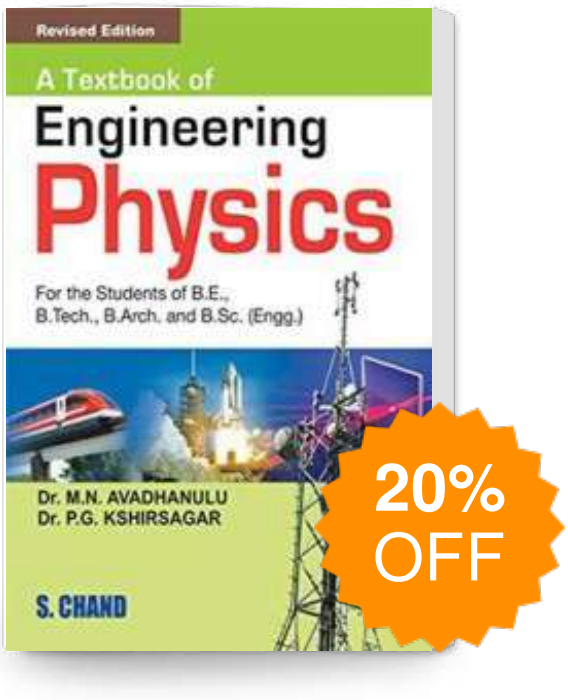
My Wife Suwarchala

Books are not paper and words but interaction with thinkers on a one-to-one basis, not of one generation but separated by hundreds and thousands of years

—Thomas Carlyle

Contents

A Textbook Of Engineering Physics



Publisher : SChand Publications ISBN : 9788121908177

Author : M. N. Avadhanulu, P. G. Kshirsagar