

W. G. DARVELL

APPLIED PHYSICS

VOLS. I-II

THE TECHNICAL COLLEGE SERIES

APPLIED PHYSICS

By

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VOLUME I



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CONTENTS

<i>Chapter</i>	<i>Page</i>
GENERAL EDITOR'S FOREWORD	v
PREFACE	vii
THE GREEK ALPHABET	xi
SYMBOLS, SIGNS AND ABBREVIATIONS	xi
LIST OF LABORATORY EXPERIMENTS	xiv
I. INTRODUCTION. FUNDAMENTAL UNITS AND MEASUREMENTS	17
II. VELOCITY AND ACCELERATION	34
III. MOTION OF A MASSIVE BODY	45
IV. WORK, ENERGY AND POWER	57
V. EQUILIBRIUM OF FORCES	68
VI. WEIGHING	79
VII. MACHINES	87
VIII. DENSITY	98
IX. HYDROSTATICS	104
X. INTRODUCTION TO HEAT. SIMPLE THERMOMETERS	132
XI. QUANTITY OF HEAT	141
XII. EXPANSION OF SOLIDS	155
XIII. EXPANSION OF LIQUIDS	165
XIV. EXPANSION OF GASES	176
XV. CHANGE OF STATE. SOLID TO LIQUID	194
XVI. CHANGE OF STATE. LIQUID TO VAPOUR	203
XVII. THE DYNAMICAL THEORY OF HEAT	226
XVIII. TRANSFERENCE OF HEAT	236
XIX. EXAMINATION QUESTIONS	249
ANSWERS	262
INDEX	267

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GENERAL EDITOR'S FOREWORD

The Technical College Series today includes many books which are outstanding in their particular fields, and it is the aim of the publishers to maintain and develop the worthy tradition of the Series while meeting in full the increasing needs of technical and scientific education.

An outstanding contribution of the technical colleges to education has been the system of National Certificates under which the Ministry of Education and the colleges work in association with leading professional institutions. National Certificate schemes now cover practically the whole field of higher technology and applied science. The Institutions of Civil, Mechanical, Electrical and Production Engineers, the Royal Institute of Chemistry, the Institute of Physics, the Institution of Metallurgists, are all associated with National Certificate schemes. There are National Certificates in Building and in Commerce, with each of which a group of professional institutions is associated. Though the pattern of National Certificate Courses was originally dictated by the needs and limitations of the evening student, the system of endorsements obtainable by further study has now brought about the result that these courses have been extended to meet the full requirements of practice in the subjects with which they deal. During recent years the system of part-time-day release of apprentices and learners has become common in all branches of industry as well as in the public services. This has effected something like a revolution in technical education; and in particular the treatment of National Certificate studies up to the standard already indicated has become much broader.

The books included in the Series will be planned to suit the requirements of three main groups: (i) the part-time and full-time students working in technical colleges for professional qualifications and university degrees; (ii) technologists, managers, and research workers in industry; (iii) teachers in technical colleges and elsewhere who require text-books of high standard, but broad enough in treatment of their subjects to be readily adaptable to local approved schemes of study.

W. E. EISHER.

PREFACE

A report issued by the Institute of Physics in 1955 stated that "it is encouraging to see that there is a great demand for courses in the National Certificates in Applied Physics. Some of the colleges in which Applied Physics has been developed are now beginning to establish 'Sandwich Courses' in Applied Physics". There are now approximately sixty technical colleges approved by the Institute for National Certificates in Applied Physics.

As each college has its own approved syllabus in this course it is difficult to give perfect coverage but, generally speaking, Volumes I and II cover the requirements for the ordinary National Certificates in Applied Physics. The preliminary examinations for the Pharmaceutical Society, Physics for the ordinary National Certificates in Chemistry, the requirements of the U.L.C.I. and U.E.I. and for those colleges who teach the Advanced Level of General Certificate of Education. Volumes III and IV are intended for the Higher National Certificate, and the relevant examinations of the Institutions of Electrical, Mechanical and Civil Engineering.

Despite variation in college courses an attempt has been made in these four books to provide a set of textbooks sufficiently flexible for use in most of the colleges.

Throughout these books the needs of the 'Sandwich Course' students have been borne in mind, and, at the beginning of the book there is a list of essential laboratory experiments which should be performed by the student who is taking these courses. Wherever possible reference is made to the applications of the principles discussed.

In optics the choice of sign convention has been made in favour of the New Cartesian system (scheme A); all the important formulae are also worked out according to the 'Real is positive' convention (scheme B).

In Electricity and Magnetism the logical order of the C.G.S. system has been followed and at the end of each chapter the principal formulae are also derived in rationalized M.K.S. units. The attention of the reader is attracted to Chapter 8 in Volume II which is devoted to a discussion of the problems of electrical units. The symbols and abbreviations adopted are those of the British Standards Institution (1954), with whose kind permission the list on page 11 is reproduced.

Thanks are due to the University of London, the Union of Lancashire and Cheshire Institutes, and the Pharmaceutical Society for permission to reproduce certain examination questions.

PREFACE

Messrs. Griffin & George have kindly lent blocks for Figures 2, 68 and 86.

Finally my grateful thanks are due to the members of staff of the Pure and Applied Physics Department of the Royal Technical College, Salford, for the valuable suggestions which they have contributed.

W. G. DARVELL.

CONTENTS

<i>Chapter</i>	<i>Page</i>
GENERAL EDITOR'S FOREWORD	v
PREFACE	vii
THE GREEK ALPHABET	xi
SYMBOLS, SIGNS AND ABBREVIATIONS	xi
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I. INTRODUCTION. FUNDAMENTAL UNITS AND MEASUREMENTS	17
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XVIII. TRANSFERENCE OF HEAT	236
XIX. EXAMINATION QUESTIONS	249
ANSWERS	262
INDEX	267

THE GREEK ALPHABET

<i>Symbol</i>		<i>Name</i>	<i>Symbol</i>		<i>Name</i>
<i>A</i>	α	alpha	<i>N</i>	ν	nu
<i>B</i>	β	beta	<i>E</i>	ξ	xi
<i>Γ</i>	γ	gamma	<i>O</i>	\omicron	omicron
<i>Δ</i>	δ	delta	<i>Π</i>	π	pi
<i>E</i>	ϵ	epsilon	<i>P</i>	ρ	rho
<i>Z</i>	ζ	zeta	<i>Σ</i>	σ	sigma
<i>H</i>	η	eta	<i>T</i>	τ	tau
<i>Θ</i>	θ	theta	<i>Υ</i>	υ	upsilon
<i>I</i>	ι	iota	<i>Φ</i>	ϕ	phi
<i>K</i>	κ	kappa	<i>X</i>	χ	chi
<i>Λ</i>	λ	lambda	<i>Ψ</i>	ψ	psi
<i>M</i>	μ	mu	<i>Ω</i>	ω	omega

Symbols, signs and abbreviations

The symbols, signs and abbreviations are, with a few exceptions, those recommended in B.S.1991: Part 1: 1954 and are reproduced by kind permission of the British Standards Institution, 2 Park Street, London, W.1.

A. Mathematical symbols

Equal to =
 Approximately equal to \simeq
 Not equal to \neq
 Identical with \equiv
 Proportional to \propto
 Greater than $>$ Equal to or greater than \geq
 Less than $<$ Equal to or less than \leq
 Parallel to \parallel
 Perpendicular to \perp
 Infinity ∞
 Square root of $\sqrt{\quad}$
 Natural logarithm of x , $\ln x$ or $\log_e x$
 Common logarithm of x , $\log x$ or $\log_{10} x$
 Ratio of circumference to diameter of circle π

B. Symbols for physical quantities.

Length l , height h ; Area A ; Volume V
 Radius r , diameter d
 Plane angle $\alpha \beta \theta \phi \psi$, etc.
 Solid angle ω
 Time t
 Wavelength λ
 Velocity v
 Acceleration a
 Gravitational acceleration g
 Mass m
 Density ρ
 Force F
 Weight W
 Pressure p
 Coefficient of friction μ
 Electromotive force E
 Potential difference V
 Electric current in electromagnetic units i
 Electric current in practical units I
 Electric charge Q
 Resistance R
 Permittivity ϵ
 Permeability μ
 Magnetic flux density B
 Magnetic field strength H
 Magnetic flux Φ
 Refractive index n
 Temperature θ
 Absolute temperature T
 Quantity of heat Q or q
 Specific heat c
 Coefficient of linear expansion α
 Coefficient of superficial expansion β
 Coefficient of cubical expansion γ

D. Abbreviations for the names of units.

Metre m	Coulomb C
Micron μ	Ampere A
Angstrom \AA	Volt V
Angle; Degree, minute, second $^{\circ} \ ' \ ''$	Ohm Ω
Square metre m^2	Inch in.
Cubic metre m^3	Foot ft.

Centimetre cm	Yard yd
Cubic centimetre cm ³	Square inch in. ²
Second s	Gallon gal
Minute min	Ounce oz
Hour h	Pound lb
Revolution per minute rev/min	Hundredweight cwt
Gram gm	Poundal pdl
Kilogram Kgm	Foot-pound ft lb
Newton N	Horse-power h.p.
Watt-hour Wh	British thermal unit B.t.u.
degree Celsius °C	
degree Kelvin °K	

E. Abbreviations for words other than names of units.

Alternating current a.c.
Boiling point b.p.
Centre of gravity c.g.
Coefficient coeff.
Degree deg.
Direct current d.c.
Electromotive force e.m.f.
Experiment expt.
Freezing point f.p.
Gram-molecule mole.
Horse power h.p.
Maximum max.
Melting point m.p.
Minimum min.
Potential difference p.d.
Specific gravity sp. gr.
Specific heat sp. ht.
Standard temperature and pressure s.t.p.
Temperature temp.
Ultra-violet u.v.
Vapour pressure v.p.
Volume vol.
Weight wt.