

Cambridge University Press

978-0-521-57507-2 - The Cambridge Handbook of Physics Formulas: 2003 Edition

Graham Woan

Frontmatter

[More information](#)

The Cambridge Handbook of Physics Formulas

The Cambridge Handbook of Physics Formulas is a quick-reference aid for students and professionals in the physical sciences and engineering. It contains more than 2 000 of the most useful formulas and equations found in undergraduate physics courses, covering mathematics, dynamics and mechanics, quantum physics, thermodynamics, solid state physics, electromagnetism, optics, and astrophysics. An exhaustive index allows the required formulas to be located swiftly and simply, and the unique tabular format crisply identifies all the variables involved.

The Cambridge Handbook of Physics Formulas comprehensively covers the major topics explored in undergraduate physics courses. It is designed to be a compact, portable, reference book suitable for everyday work, problem solving, or exam revision. All students and professionals in physics, applied mathematics, engineering, and other physical sciences will want to have this essential reference book within easy reach.

Graham Woan is Professor of Astrophysics in the School of Physics and Astronomy at the University of Glasgow. Prior to this he taught physics at the University of Cambridge where he also received his degree in Natural Sciences, specialising in physics, and his PhD, in radio astronomy. His research interests range widely with a special focus on low-frequency radio astronomy. His publications span journals as diverse as *Astronomy & Astrophysics*, *Geophysical Research Letters*, *Advances in Space Science*, the *Journal of Navigation* and *Emergency Prehospital Medicine*. He was co-developer of the revolutionary CURSOR radio positioning system, which uses existing broadcast transmitters to determine position, and he is the designer of the Glasgow Millennium Sundial.

Cambridge University Press
978-0-521-57507-2 - The Cambridge Handbook of Physics Formulas: 2003 Edition
Graham Woan
Frontmatter
[More information](#)

Cambridge University Press

978-0-521-57507-2 - The Cambridge Handbook of Physics Formulas: 2003 Edition

Graham Woan

Frontmatter

[More information](#)

The Cambridge Handbook of Physics Formulas

2003 Edition

GRAHAM WOAN

School of Physics & Astronomy

University of Glasgow



CAMBRIDGE
UNIVERSITY PRESS

Cambridge University Press
978-0-521-57507-2 - The Cambridge Handbook of Physics Formulas: 2003 Edition
Graham Woan
Frontmatter
[More information](#)

CAMBRIDGE
UNIVERSITY PRESS

32 Avenue of the Americas, New York NY 10013-2473, USA

Cambridge University Press is part of the University of Cambridge.
It furthers the University's mission by disseminating knowledge in the pursuit of
education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9780521575072

© Cambridge University Press 2000

This publication is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without the written
permission of Cambridge University Press.

First published 2000
10th printing 2010

A catalogue record for this publication is available from the British Library
Library of Congress Cataloguing in Publication data

Woan, Graham, 1963–
The Cambridge handbook of physics formulas / Graham Woan.
p. cm.
ISBN 0-521-57349-1 (hardback) – ISBN 0-521-57507-9 (pbk.)
1. Physics – Formulas. I. Title.
QC61.W67 1999
530'.02'12 – dc21 99-15228

CIP

ISBN 978-0-521-57349-8 Hardback
ISBN 978-0-521-57507-2 Paperback

Cambridge University Press has no responsibility for the persistence or accuracy of
URLs for external or third-party internet websites referred to in this publication,
and does not guarantee that any content on such websites is, or will remain, accurate
or appropriate.

Contents

Preface	<i>page vii</i>
How to use this book	1
1 Units, constants, and conversions	3
1.1 Introduction, 3 • 1.2 SI units, 4 • 1.3 Physical constants, 6 • 1.4 Converting between units, 10 • 1.5 Dimensions, 16 • 1.6 Miscellaneous, 18	
2 Mathematics	19
2.1 Notation, 19 • 2.2 Vectors and matrices, 20 • 2.3 Series, summations, and progressions, 27 • 2.4 Complex variables, 30 • 2.5 Trigonometric and hyperbolic formulas, 32 • 2.6 Mensuration, 35 • 2.7 Differentiation, 40 • 2.8 Integration, 44 • 2.9 Special functions and polynomials, 46 • 2.10 Roots of quadratic and cubic equations, 50 • 2.11 Fourier series and transforms, 52 • 2.12 Laplace transforms, 55 • 2.13 Probability and statistics, 57 • 2.14 Numerical methods, 60	
3 Dynamics and mechanics	63
3.1 Introduction, 63 • 3.2 Frames of reference, 64 • 3.3 Gravitation, 66 • 3.4 Particle motion, 68 • 3.5 Rigid body dynamics, 74 • 3.6 Oscillating systems, 78 • 3.7 Generalised dynamics, 79 • 3.8 Elasticity, 80 • 3.9 Fluid dynamics, 84	
4 Quantum physics	89
4.1 Introduction, 89 • 4.2 Quantum definitions, 90 • 4.3 Wave mechanics, 92 • 4.4 Hydrogenic atoms, 95 • 4.5 Angular momentum, 98 • 4.6 Perturbation theory, 102 • 4.7 High energy and nuclear physics, 103	
5 Thermodynamics	105
5.1 Introduction, 105 • 5.2 Classical thermodynamics, 106 • 5.3 Gas laws, 110 • 5.4 Kinetic theory, 112 • 5.5 Statistical thermodynamics, 114 • 5.6 Fluctuations and noise, 116 • 5.7 Radiation processes, 118	

6	<u>Solid state physics</u>	123
	6.1 Introduction, 123 • 6.2 Periodic table, 124 • 6.3 Crystalline structure, 126 • 6.4 Lattice dynamics, 129 • 6.5 Electrons in solids, 132	
7	<u>Electromagnetism</u>	135
	7.1 Introduction, 135 • 7.2 Static fields, 136 • 7.3 Electromagnetic fields (general), 139 • 7.4 Fields associated with media, 142 • 7.5 Force, torque, and energy, 145 • 7.6 LCR circuits, 147 • 7.7 Transmission lines and waveguides, 150 • 7.8 Waves in and out of media, 152 • 7.9 Plasma physics, 156	
8	<u>Optics</u>	161
	8.1 Introduction, 161 • 8.2 Interference, 162 • 8.3 Fraunhofer diffraction, 164 • 8.4 Fresnel diffraction, 166 • 8.5 Geometrical optics, 168 • 8.6 Polarisation, 170 • 8.7 Coherence (scalar theory), 172 • 8.8 Line radiation, 173	
9	<u>Astrophysics</u>	175
	9.1 Introduction, 175 • 9.2 Solar system data, 176 • 9.3 Coordinate transformations (astronomical), 177 • 9.4 Observational astrophysics, 179 • 9.5 Stellar evolution, 181 • 9.6 Cosmology, 184	
	Index	187

Preface

In *A Brief History of Time*, Stephen Hawking relates that he was warned against including equations in the book because “each equation... would halve the sales.” Despite this dire prediction there is, for a scientific audience, some attraction in doing the exact opposite.

The reader should not be misled by this exercise. Although the equations and formulas contained here underpin a good deal of physical science they are useless unless the reader *understands* them. Learning physics is not about remembering equations, it is about appreciating the natural structures they express. Although its format should help make some topics clearer, this book is not designed to teach new physics; there are many excellent textbooks to help with that. It is intended to be useful rather than pedagogically complete, so that students can use it for revision and for structuring their knowledge *once they understand the physics*. More advanced users will benefit from having a compact, internally consistent, source of equations that can quickly deliver the relationship they require in a format that avoids the need to sift through pages of rubric.

Some difficult decisions have had to be made to achieve this. First, to be short the book only includes ideas that can be expressed succinctly in equations, without resorting to lengthy explanation. A small number of important topics are therefore absent. For example, Liouville’s theorem can be algebraically succinct ($\dot{q} = 0$) but is meaningless unless \dot{q} is thoroughly (and carefully) explained. Anyone who already understands what \dot{q} represents will probably not need reminding that it equals zero. Second, empirical equations with numerical coefficients have been largely omitted, as have topics significantly more advanced than are found at undergraduate level. There are simply too many of these to be sensibly and confidently edited into a short handbook. Third, physical data are largely absent, although a periodic table, tables of physical constants, and data on the solar system are all included. Just a sighting of the marvellous (but dimensionally misnamed) *CRC Handbook of Chemistry and Physics* should be enough to convince the reader that a good science data book is thick.

Inevitably there is personal choice in what should or should not be included, and you may feel that an equation that meets the above criteria is missing. If this is the case, I would be delighted to hear from you so it can be considered for a subsequent edition. Contact details are at the end of this preface. Likewise, if you spot an error or an inconsistency then please let me know and I will post an erratum on the web page.

Cambridge University Press

978-0-521-57507-2 - The Cambridge Handbook of Physics Formulas: 2003 Edition

Graham Woan

Frontmatter

[More information](#)

Acknowledgments This venture is founded on the generosity of colleagues in Glasgow and Cambridge whose inputs have strongly influenced the final product. The expertise of Dave Clarke, Declan Diver, Peter Duffett-Smith, Wolf-Gerrit Früh, Martin Hendry, Rico Ignace, David Ireland, John Simmons, and Harry Ward have been central to its production, as have the linguistic skills of Katie Lowe. I would also like to thank Richard Barrett, Matthew Cartmell, Steve Gull, Martin Hendry, Jim Hough, Darren McDonald, and Ken Riley who all agreed to field-test the book and gave invaluable feedback.

My greatest thanks though are to John Shakeshaft who, with remarkable knowledge and skill, worked through the entire manuscript more than once during its production and whose legendary red pen hovered over (or descended upon) every equation in the book. What errors remain are, of course, my own, but I take comfort from the fact that without John they would be much more numerous.

Contact information A website containing up-to-date information on this handbook and contact details can be found through the Cambridge University Press web pages at us.cambridge.org (North America) or uk.cambridge.org (United Kingdom), or directly at radio.astro.gla.ac.uk/hbhome.html.

Production notes This book was typeset by the author in L^AT_EX 2_ε using the CUP Times fonts. The software packages used were *WinEdt*, MiK_TE_X, *Mayura Draw*, *Gnuplot*, *Ghostschrift*, *Ghostview*, and *Maple V*.

Comments on the 2003 edition I am grateful to all those who have suggested improvements, in particular Javier Hasbun, Martin Hendry, Wolfgang Jitschin, Joseph Katz, and Alan Watson. Although this edition contains only minor revisions to the original its production was also an opportunity to update the physical constants and periodic table entries and to reflect recent developments in cosmology.

How to use this book

The format is largely self-explanatory, but a few comments may be helpful. Although it is very tempting to flick through the pages to find what you are looking for, the best starting point is the index. I have tried to make this as extensive as possible, and many equations are indexed more than once. Equations are listed both with their equation number (in square brackets) and the page on which they can be found. The equations themselves are grouped into self-contained and boxed “panels” on the pages. Each panel represents a separate topic, and you will find descriptions of all the variables used at the right-hand side of the panel, usually adjacent to the first equation in which they are used. You should therefore not need to stray outside the panel to understand the notation. Both the panel as a whole and its individual entries may have footnotes, shown below the panel. Be aware of these, as they contain important additional information and conditions relevant to the topic.

Although the panels are self-contained they may use concepts defined elsewhere in the handbook. Often these are cross-referenced, but again the index will help you to locate them if necessary. Notations and definitions are uniform over subject areas unless stated otherwise.