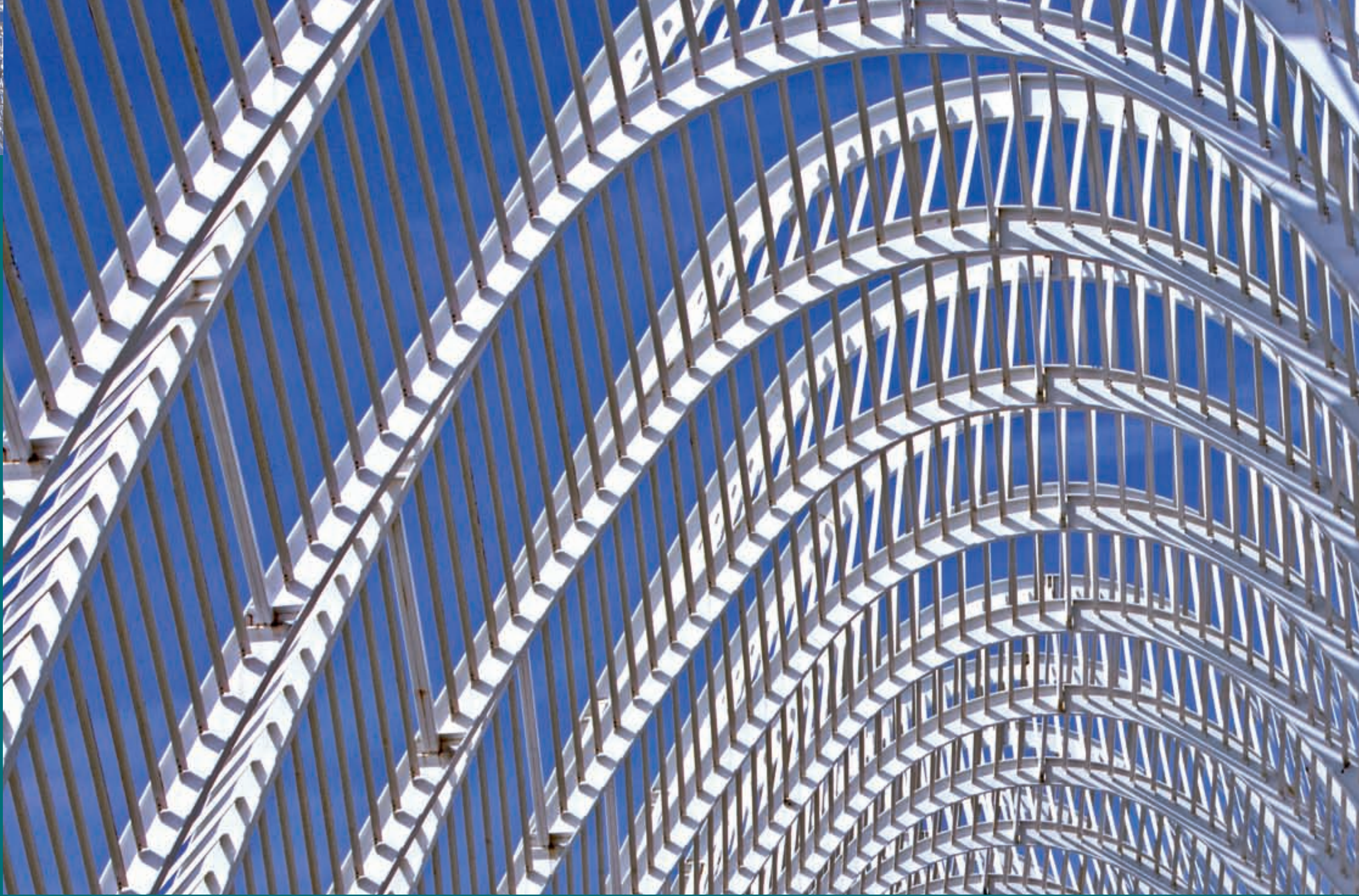
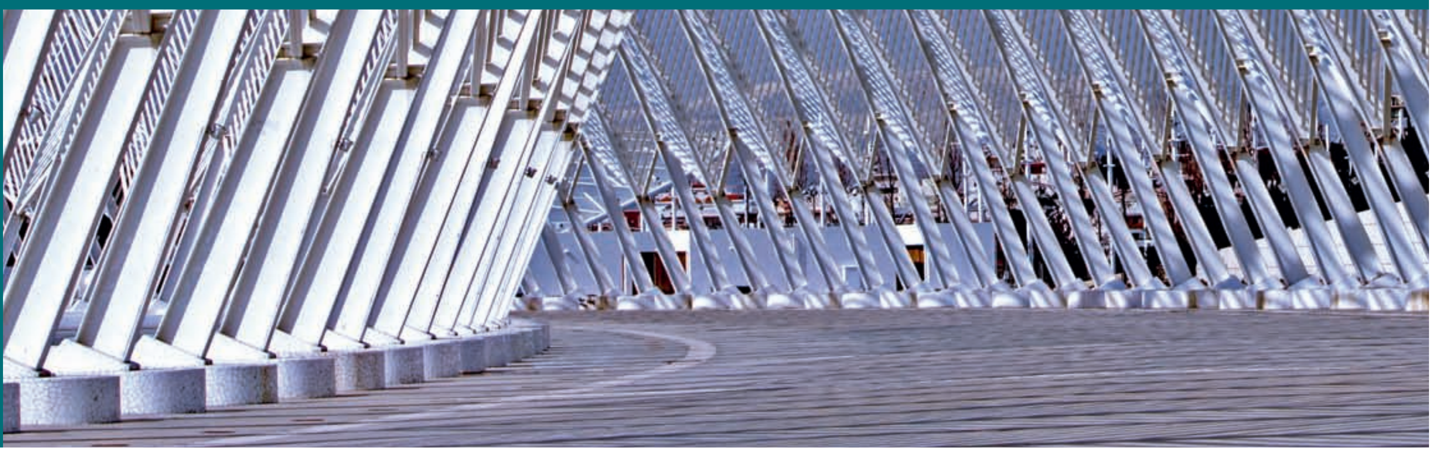


Advanced Modern Engineering Mathematics

fourth edition

Glyn James



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Advanced Modern Engineering Mathematics

Fourth Edition

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and

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Edinburgh Gate
Harlow
Essex CM20 2JE
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First published 1993
Second edition 1999
Third edition 2004
Fourth edition 2011

ISBN: 978-0-273-71923-6

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data
Advanced modern engineering mathematics / Glyn James ... [et al.]. –
4th ed.
p. cm.
ISBN 978-0-273-71923-6 (pbk.)
1. Engineering mathematics. I. James, Glyn.
TA330.A38 2010
620.001′51—dc22
2010031592

10 9 8 7 6 5 4 3 2 1
14 13 12 11 10

Typeset in 10/12pt Times by 35
Printed by Ashford Colour Press Ltd., Gosport

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Preface

Throughout the course of history, engineering and mathematics have developed in parallel. All branches of engineering depend on mathematics for their description and there has been a steady flow of ideas and problems from engineering that has stimulated and sometimes initiated branches of mathematics. Thus it is vital that engineering students receive a thorough grounding in mathematics, with the treatment related to their interests and problems. As with the previous editions, this has been the motivation for the production of this fourth edition – a companion text to the fourth edition of *Modern Engineering Mathematics*, this being designed to provide a first-level core studies course in mathematics for undergraduate programmes in all engineering disciplines. Building on the foundations laid in the companion text, this book gives an extensive treatment of some of the more advanced areas of mathematics that have applications in various fields of engineering, particularly as tools for computer-based system modelling, analysis and design. Feedback, from users of the previous editions, on subject content has been highly positive indicating that it is sufficiently broad to provide the necessary second-level, or optional, studies for most engineering programmes, where in each case a selection of the material may be made. Whilst designed primarily for use by engineering students, it is believed that the book is also suitable for use by students of applied mathematics and the physical sciences.

Although the pace of the book is at a somewhat more advanced level than the companion text, the philosophy of learning by doing is retained with continuing emphasis on the development of students' ability to use mathematics with understanding to solve engineering problems. Recognizing the increasing importance of mathematical modelling in engineering practice, many of the worked examples and exercises incorporate mathematical models that are designed both to provide relevance and to reinforce the role of mathematics in various branches of engineering. In addition, each chapter contains specific sections on engineering applications, and these form an ideal framework for individual, or group, study assignments, thereby helping to reinforce the skills of mathematical modelling, which are seen as essential if engineers are to tackle the increasingly complex systems they are being called upon to analyse and design. The importance of numerical methods in problem solving is also recognized, and its treatment is integrated with the analytical work throughout the book.

Much of the feedback from users relates to the role and use of software packages, particularly symbolic algebra packages. Without making it an essential requirement the authors have attempted to highlight throughout the text situations where the user could make effective use of software. This also applies to exercises and, indeed, a limited number have been introduced for which the use of such a package is essential. Whilst any appropriate piece of software can be used, the authors recommend the use of MATLAB and/or MAPLE. In this new edition more copious reference to the use of these two packages is made throughout the text, with commands or codes introduced and illustrated. When indicated, students are strongly recommended to use these packages to check their solutions to exercises. This is not only to help develop proficiency in their use, but also to enable students to appreciate the necessity of having a sound knowledge of the underpinning mathematics if such packages are to be used effectively. Throughout the book two icons are used:

- An open screen indicates that the use of a software package would be useful (e.g. for checking solutions) but not essential.
- A closed screen indicates that the use of a software package is essential or highly desirable.

As indicated earlier, feedback on content from users of previous editions has been favourable, and consequently no new chapter has been introduced. However, in response to feedback the order of presentation of chapters has been changed, with a view to making it more logical and appealing to users. This re-ordering has necessitated some redistribution of material both within and across some of the chapters. Another new feature is the introduction of the use of colour. It is hoped that this will make the text more accessible and student-friendly. Also, in response to feedback individual chapters have been reviewed and updated accordingly. The most significant changes are:

- Chapter 1 Matrix Analysis: Inclusion of new sections on ‘Singular value decomposition’ and ‘Lyapunov stability analysis’.
- Chapter 5 Laplace transform: Following re-ordering of chapters a more unified and extended treatment of transfer functions/transfer matrices for continuous-time state-space models has been included.
- Chapter 6 Z-transforms: Inclusion of a new section on ‘Discretization of continuous-time state-space models’.
- Chapter 8 Fourier transform: Inclusion of a new section on ‘Direct design of digital filters and windows’.
- Chapter 9 Partial differential equations: The treatment of first order equations has been extended and a new section on ‘Integral solution’ included.
- Chapter 10 Optimization: Inclusion of a new section on ‘Least squares’.

A comprehensive Solutions Manual is available free of charge to lecturers adopting this textbook. It will also be available for download via the Web at: www.pearsoned.co.ck/james.

Acknowledgements

The authoring team is extremely grateful to all the reviewers and users of the text who have provided valuable comments on previous editions of this book. Most of this has been highly constructive and very much appreciated. The team has continued to enjoy the full support of a very enthusiastic production team at Pearson Education and wishes to thank all those concerned. Finally I would like to thank my wife, Dolan, for her full support throughout the preparation of this text and its previous editions.

Glyn James
Coventry University
July 2010

About the Authors

Glyn James retired as Dean of the School of Mathematical and Information Sciences at Coventry University in 2001 and is now Emeritus Professor in Mathematics at the University. He graduated from the University College of Wales, Cardiff in the late 1950s, obtaining first class honours degrees in both Mathematics and Chemistry. He obtained a PhD in Engineering Science in 1971 as an external student of the University of Warwick. He has been employed at Coventry since 1964 and held the position of the Head of Mathematics Department prior to his appointment as Dean in 1992. His research interests are in control theory and its applications to industrial problems. He also has a keen interest in mathematical education, particularly in relation to the teaching of engineering mathematics and mathematical modelling. He was co-chairman of the European Mathematics Working Group established by the European Society for Engineering Education (SEFI) in 1982, a past chairman of the Education Committee of the Institute of Mathematics and its Applications (IMA), and a member of the Royal Society Mathematics Education Subcommittee. In 1995 he was chairman of the Working Group that produced the report 'Mathematics Matters in Engineering' on behalf of the professional bodies in engineering and mathematics within the UK. He is also a member of the editorial/advisory board of three international journals. He has published numerous papers and is co-editor of five books on various aspects of mathematical modelling. He is a past Vice-President of the IMA and has also served a period as Honorary Secretary of the Institute. He is a Chartered Mathematician and a Fellow of the IMA.

David Burley retired from the University of Sheffield in 1998. He graduated in mathematics from King's College, University of London in 1955 and obtained his PhD in mathematical physics. After working in the University of Glasgow, he spent most of his academic career in the University of Sheffield, being Head of Department for six years. He has long experience of teaching engineering students and has been particularly interested in encouraging students to construct mathematical models in physical and biological contexts to enhance their learning. His research work has ranged through statistical mechanics, optimization and fluid mechanics. He has particular interest in the flow of molten glass in a variety of situations and the application of results in the glass industry. Currently he is involved in a large project concerning heat transfer problems in the deep burial of nuclear waste.

Dick Clements is Emeritus Professor in the Department of Engineering Mathematics at Bristol University. He read for the Mathematical Tripos, matriculating at Christ's College, Cambridge in 1966. He went on to take a PGCE at Leicester University School of Education (1969–70) before returning to Cambridge to research a PhD in Aeronautical Engineering (1970–73). In 1973 he was appointed Lecturer in Engineering Mathematics at Bristol University and has taught mathematics to engineering students ever since, becoming successively Senior Lecturer, Reader and Professorial Teaching Fellow. He has undertaken research in a wide range of engineering topics but is particularly interested in mathematical modelling and in new approaches to the teaching of mathematics to engineering students. He has published numerous papers and one previous book, *Mathematical Modelling: A Case Study Approach*. He is a Chartered Engineer, a Chartered Mathematician, a member of the Royal Aeronautical Society, a Fellow of the Institute of Mathematics and Its Applications, an Associate Fellow of the Royal Institute of Navigation, and a Fellow of the Higher Education Academy. He retired from full time work in 2007 but continues to teach and pursue his research interests on a part time basis.

Phil Dyke is Professor of Applied Mathematics at the University of Plymouth. He was Head of School of Mathematics and Statistics for 18 years then Head of School of Computing, Communications and Electronics for four years but he now devotes his time to teaching and research. After graduating with a first in mathematics he gained a PhD in coastal engineering modelling. He has over 35 years' experience teaching undergraduates, most of this teaching to engineering students. He has run an international research group since 1981 applying mathematics to coastal engineering and shallow sea dynamics. Apart from contributing to these engineering mathematics books, he has written seven textbooks on mathematics and marine science, and still enjoys trying to solve environmental problems using simple mathematical models.

John Searl was Director of the Edinburgh Centre for Mathematical Education at the University of Edinburgh before his recent retirement. As well as lecturing on mathematical education, he taught service courses for engineers and scientists. His most recent research concerned the development of learning environments that make for the effective learning of mathematics for 16–20 year olds. As an applied mathematician who worked collaboratively with (among others) engineers, physicists, biologists and pharmacologists, he is keen to develop the problem-solving skills of students and to provide them with opportunities to display their mathematical knowledge within a variety of practical contexts. These contexts develop the extended reasoning needed in all fields of engineering.

Nigel Steele was Head of Mathematics at Coventry University until his retirement in 2004. He has had a career-long interest in engineering mathematics and its teaching, particularly to electrical and control engineers. Since retirement he has been Emeritus Professor of Mathematics at Coventry, combining this with the duties of Honorary Secretary of the Institute of Mathematics and its Applications. Having responsibility for the Institute's education matters he became heavily involved with a highly successful project aimed at encouraging more people to study for mathematics and other 'maths-rich' courses (for example Engineering) at University. He also assisted in the development of the mathematics content for the advanced Engineering Diploma, working to ensure that students were properly prepared for the study of Engineering in Higher Education.

Jerry Wright is a Lead Member of Technical Staff at the AT&T Shannon Laboratory, New Jersey, USA. He graduated in Engineering (BSc and PhD at the University of Southampton) and in Mathematics (MSc at the University of London) and worked at the National Physical Laboratory before moving to the University of Bristol in 1978. There he acquired wide experience in the teaching of mathematics to students of engineering, and became Senior Lecturer in Engineering Mathematics. He held a Royal Society Industrial Fellowship for 1994, and is a Fellow of the Institute of Mathematics and its Applications. In 1996 he moved to AT&T Labs (formerly part of Bell labs) to continue his research in spoken language understanding, human/computer dialog systems, and data mining.

Publisher's Acknowledgements

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Text
Extract from *Signal Processing in Electronic Communications*, *ISBN 1898563233*, 1 ed., Woodhead Publishing Ltd (Chapman, N, Goodhall, D, Steele, N).

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