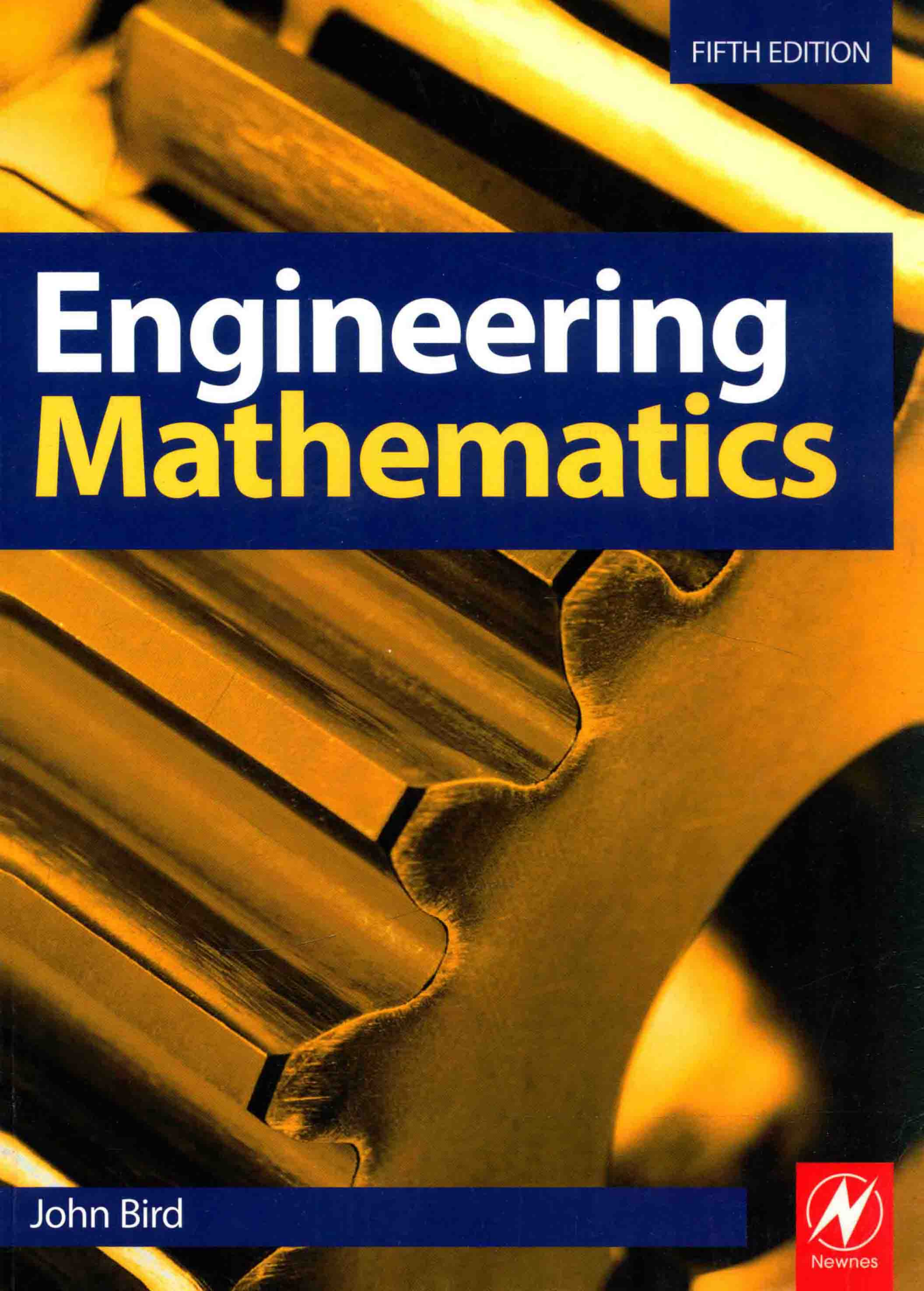
FIFTH EDITION
Engineering
Mathematics
John Bird
Newnes

Engineering Mathematics

Fifth edition

John Bird BSc(Hons), CEng, CSci, CMath, FIET, MIEE, FIIE, FIMA, FCollT

AMSTERDAM • BOSTON • HEIDELBERG • LONDON • NEW YORK • OXFORD
PARIS • SAN DIEGO • SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

ELSEVIER

Newnes is an imprint of Elsevier

Newnes

Newnes is an imprint of Elsevier
Linacre House, Jordan Hill, Oxford OX2 8DP, UK
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA

First edition 1989
Second edition 1996
Reprinted 1998 (twice), 1999
Third edition 2001
Fourth edition 2003
Reprinted 2004
Fifth edition 2007

Copyright © 2001, 2003, 2007, John Bird. Published by Elsevier Ltd. All rights reserved

The right of John Bird to be identified as the author of this work has been asserted in accordance with the Copyright, Designs and Patents Act 1988

Permissions may be sought directly from Elsevier's Science & Technology Rights Department in Oxford, UK: phone (+44) (0) 1865 843830; fax (+44) (0) 1865 853333; email: permissions@elsevier.com. Alternatively you can submit your request online by visiting the Elsevier web site at http://elsevier.com/locate/permissions, and selecting *Obtaining permission to use Elsevier material*

Notice
No responsibility is assumed by the publisher for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the material herein. Because of rapid advances in the medical sciences, in particular, independent verification of diagnoses and drug dosages should be made

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

Library of Congress Cataloguing in Publication Data
A catalogue record for this book is available from the Library of Congress

ISBN: 978-0-75-068555-9

For information on all Newnes publications
visit our website at www.books.elsevier.com

Typeset by Charon Tec Ltd (A Macmillan Company), Chennai, India
www.charontec.com
Printed and bound in The Netherlands

7 8 9 10 11 11 10 9 8 7 6 5 4 3 2 1

Working together to grow
libraries in developing countries
www.elsevier.com | www.bookaid.org | www.sabre.org
ELSEVIER BOOK AID International Sabre Foundation

Engineering Mathematics

In memory of Elizabeth

试读结束：需要全本请在线购买： www.ertongbook.com

Preface

Engineering Mathematics 5th Edition covers a wide range of syllabus requirements. In particular, the book is most suitable for the latest **National Certificate and Diploma courses and City & Guilds syllabuses in Engineering**.

This text will provide a foundation in mathematical principles, which will enable students to solve mathematical, scientific and associated engineering principles. In addition, the material will provide engineering applications and mathematical principles necessary for advancement onto a range of Incorporated Engineer degree profiles. It is widely recognised that a students' ability to use mathematics is a key element in determining subsequent success. First year undergraduates who need some remedial mathematics will also find this book meets their needs.

In **Engineering Mathematics 5th Edition**, new material is included on inequalities, differentiation of parametric equations, implicit and logarithmic functions and an introduction to differential equations. Because of restraints on extent, chapters on linear correlation, linear regression and sampling and estimation theories have been removed. However, **these three chapters are available to all via the internet**.

A new feature of this fifth edition is that a **free Internet download** is available of a **sample of solutions** (some 1250) of the 1750 further problems contained in the book – see below.

Another new feature is a **free Internet download (available for lecturers only) of all 500 illustrations** contained in the text – see below.

Throughout the text theory is introduced in each chapter by a simple outline of essential definitions, formulae, laws and procedures. The theory is kept to a minimum, for problem solving is extensively used to establish and exemplify the theory. It is intended that readers will gain real understanding through seeing problems solved and then through solving similar problems themselves.

For clarity, the text is divided into **eleven topic areas**, these being: number and algebra, mensuration, trigonometry, graphs, vectors, complex numbers, statistics, differential calculus, integral calculus, further number and algebra and differential equations.

This new edition covers, in particular, the following syllabuses:

(i) **Mathematics for Technicians**, the core unit for **National Certificate/Diploma** courses in Engineering, to include all or part of the following chapters:
   1. **Algebraic methods:** 2, 5, 11, 13, 14, 28, 30 (1, 4, 8, 9 and 10 for revision)
   2. **Trigonometric methods and areas and volumes:** 18–20, 22–25, 33, 34
   3. **Statistical methods:** 37, 38
   4. **Elementary calculus:** 42, 48, 55

(ii) **Further Mathematics for Technicians,** the optional unit for **National Certificate/Diploma** courses in Engineering, to include all or part of the following chapters:
   1. **Advanced graphical techniques:** 29–31
   2. **Algebraic techniques:** 15, 35, 38
   2. **Trigonometry:** 23, 26, 27, 34
   3. **Calculus:** 42–44, 48, 55–56

(iii) **The mathematical contents of Electrical and Electronic Principles units of the City & Guilds Level 3 Certificate in Engineering (2800).**

(iv) Any **introductory/access/foundation course** involving Engineering Mathematics **at University, Colleges of Further and Higher education and in schools**.

Each topic considered in the text is presented in a way that assumes in the reader little previous knowledge of that topic.

Engineering Mathematics 5th Edition provides a follow-up to **Basic Engineering Mathematics** and a lead into **Higher Engineering Mathematics 5th Edition**.

This textbook contains over **1000 worked problems**, followed by some **1750 further problems** (all **with**

answers). The further problems are contained within some **220 Exercises**; each Exercise follows on directly from the relevant section of work, every two or three pages. In addition, the text contains **238 multiple-choice questions**. Where at all possible, the problems mirror practical situations found in engineering and science. **500 line diagrams** enhance the understanding of the theory.

At regular intervals throughout the text are some **18 Revision tests** to check understanding. For example, Revision test 1 covers material contained in Chapters 1 to 4, Revision test 2 covers the material in Chapters 5 to 8, and so on. These Revision Tests do not have answers given since it is envisaged that lecturers could set the tests for students to attempt as part of their course structure. Lecturers' may obtain a complimentary set of solutions of the Revision Tests in an **Instructor's Manual** available from the publishers via the internet – see below.

A list of **Essential Formulae** is included in the Instructor's Manual for convenience of reference. **Learning by Example** is at the heart of **Engineering Mathematics 5th Edition**.

JOHN BIRD
Royal Naval School of Marine Engineering,
HMS Sultan,
formerly University of Portsmouth and
Highbury College,
Portsmouth

Free web downloads

Additional material on statistics

Chapters on Linear correlation, Linear regression and Sampling and estimation theories are available for free to students and lecturers at http://books.elsevier.com/companions/9780750685559

In addition, a suite of support material is available to lecturers only from Elsevier's textbook website.

Solutions manual

Within the text are some 1750 further problems arranged within 220 Exercises. A sample of over 1250 worked solutions has been prepared for lecturers.

Instructor's manual

This manual provides full worked solutions and mark scheme for all 18 Revision Tests in this book.

Illustrations

Lecturers can also download electronic files for all illustrations in this fifth edition.

To access the lecturer support material, please go to http://textbooks.elsevier.com and search for the book. On the book web page, you will see a link to the Instructor Manual on the right. If you do not have an account for the textbook website already, you will need to register and request access to the book's subject area. If you already have an account but do not have access to the right subject area, please follow the 'Request Access to this Subject Area' link at the top of the subject area homepage.

Contents

Preface xii

Section 1 Number and Algebra 1

1 Revision of fractions, decimals and percentages 3
- 1.1 Fractions 3
- 1.2 Ratio and proportion 5
- 1.3 Decimals 6
- 1.4 Percentages 9

2 Indices, standard form and engineering notation 11
- 2.1 Indices 11
- 2.2 Worked problems on indices 12
- 2.3 Further worked problems on indices 13
- 2.4 Standard form 15
- 2.5 Worked problems on standard form 15
- 2.6 Further worked problems on standard form 16
- 2.7 Engineering notation and common prefixes 17

3 Computer numbering systems 19
- 3.1 Binary numbers 19
- 3.2 Conversion of binary to decimal 19
- 3.3 Conversion of decimal to binary 20
- 3.4 Conversion of decimal to binary via octal 21
- 3.5 Hexadecimal numbers 23

4 Calculations and evaluation of formulae 27
- 4.1 Errors and approximations 27
- 4.2 Use of calculator 29
- 4.3 Conversion tables and charts 31
- 4.4 Evaluation of formulae 32

Revision Test 1 37

5 Algebra 38
- 5.1 Basic operations 38
- 5.2 Laws of Indices 40
- 5.3 Brackets and factorisation 42
- 5.4 Fundamental laws and precedence 44
- 5.5 Direct and inverse proportionality 46

6 Further algebra 48
- 6.1 Polynominal division 48
- 6.2 The factor theorem 50
- 6.3 The remainder theorem 52

7 Partial fractions 54
- 7.1 Introduction to partial fractions 54
- 7.2 Worked problems on partial fractions with linear factors 54
- 7.3 Worked problems on partial fractions with repeated linear factors 57
- 7.4 Worked problems on partial fractions with quadratic factors 58

8 Simple equations 60
- 8.1 Expressions, equations and identities 60
- 8.2 Worked problems on simple equations 60
- 8.3 Further worked problems on simple equations 62
- 8.4 Practical problems involving simple equations 64
- 8.5 Further practical problems involving simple equations 65

Revision Test 2 67

9 Simultaneous equations 68
- 9.1 Introduction to simultaneous equations 68
- 9.2 Worked problems on simultaneous equations in two unknowns 68
- 9.3 Further worked problems on simultaneous equations 70
- 9.4 More difficult worked problems on simultaneous equations 72
- 9.5 Practical problems involving simultaneous equations 73

10 Transposition of formulae 77
- 10.1 Introduction to transposition of formulae 77

10.2 Worked problems on transposition of formulae 77
10.3 Further worked problems on transposition of formulae 78
10.4 Harder worked problems on transposition of formulae 80

11 Quadratic equations 83
11.1 Introduction to quadratic equations 83
11.2 Solution of quadratic equations by factorisation 83
11.3 Solution of quadratic equations by 'completing the square' 85
11.4 Solution of quadratic equations by formula 87
11.5 Practical problems involving quadratic equations 88
11.6 The solution of linear and quadratic equations simultaneously 90

12 Inequalities 91
12.1 Introduction in inequalities 91
12.2 Simple inequalities 91
12.3 Inequalities involving a modulus 92
12.4 Inequalities involving quotients 93
12.5 Inequalities involving square functions 94
12.6 Quadratic inequalities 95

13 Logarithms 97
13.1 Introduction to logarithms 97
13.2 Laws of logarithms 97
13.3 Indicial equations 100
13.4 Graphs of logarithmic functions 101

Revision Test 3 102

14 Exponential functions 103
14.1 The exponential function 103
14.2 Evaluating exponential functions 103
14.3 The power series for e^x 104
14.4 Graphs of exponential functions 106
14.5 Napierian logarithms 108
14.6 Evaluating Napierian logarithms 108
14.7 Laws of growth and decay 110

15 Number sequences 114
15.1 Arithmetic progressions 114
15.2 Worked problems on arithmetic progressions 114
15.3 Further worked problems on arithmetic progressions 115
15.4 Geometric progressions 117
15.5 Worked problems on geometric progressions 118
15.6 Further worked problems on geometric progressions 119
15.7 Combinations and permutations 120

16 The binomial series 122
16.1 Pascal's triangle 122
16.2 The binomial series 123
16.3 Worked problems on the binomial series 123
16.4 Further worked problems on the binomial series 125
16.5 Practical problems involving the binomial theorem 127

17 Solving equations by iterative methods 130
17.1 Introduction to iterative methods 130
17.2 The Newton–Raphson method 130
17.3 Worked problems on the Newton–Raphson method 131

Revision Test 4 133

Multiple choice questions on Chapters 1–17 134

Section 2 Mensuration 139

18 Areas of plane figures 141
18.1 Mensuration 141
18.2 Properties of quadrilaterals 141
18.3 Worked problems on areas of plane figures 142
18.4 Further worked problems on areas of plane figures 145
18.5 Worked problems on areas of composite figures 147
18.6 Areas of similar shapes 148

19 The circle and its properties 150
19.1 Introduction 150
19.2 Properties of circles 150
19.3 Arc length and area of a sector 152
19.4 Worked problems on arc length and sector of a circle 153
19.5 The equation of a circle 155

20 Volumes and surface areas of common solids 157
20.1 Volumes and surface areas of regular solids 157
20.2 Worked problems on volumes and surface areas of regular solids 157
20.3 Further worked problems on volumes and surface areas of regular solids 160
20.4 Volumes and surface areas of frusta of pyramids and cones 164
20.5 The frustum and zone of a sphere 167
20.6 Prismoidal rule 170
20.7 Volumes of similar shapes 172

21 Irregular areas and volumes and mean values of waveforms 174
21.1 Area of irregular figures 174
21.2 Volumes of irregular solids 176
21.3 The mean or average value of a waveform 177

Revision Test 5 182

Section 3 Trigonometry 185

22 Introduction to trigonometry 187
22.1 Trigonometry 187
22.2 The theorem of Pythagoras 187
22.3 Trigonometric ratios of acute angles 188
22.4 Fractional and surd forms of trigonometric ratios 190
22.5 Solution of right-angled triangles 191
22.6 Angle of elevation and depression 193
22.7 Evaluating trigonometric ratios of any angles 195
22.8 Trigonometric approximations for small angles 197

23 Trigonometric waveforms 199
23.1 Graphs of trigonometric functions 199
23.2 Angles of any magnitude 199
23.3 The production of a sine and cosine wave 202
23.4 Sine and cosine curves 202
23.5 Sinusoidal form $A\sin(\omega t \pm \alpha)$ 206
23.6 Waveform harmonics 209

24 Cartesian and polar co-ordinates 211
24.1 Introduction 211
24.2 Changing from Cartesian into polar co-ordinates 211
24.3 Changing from polar into Cartesian co-ordinates 213
24.4 Use of $R \rightarrow P$ and $P \rightarrow R$ functions on calculators 214

Revision Test 6 215

25 Triangles and some practical applications 216
25.1 Sine and cosine rules 216
25.2 Area of any triangle 216
25.3 Worked problems on the solution of triangles and their areas 216
25.4 Further worked problems on the solution of triangles and their areas 218
25.5 Practical situations involving trigonometry 220
25.6 Further practical situations involving trigonometry 222

26 Trigonometric identities and equations 225
26.1 Trigonometric identities 225
26.2 Worked problems on trigonometric identities 225
26.3 Trigonometric equations 226
26.4 Worked problems (i) on trigonometric equations 227
26.5 Worked problems (ii) on trigonometric equations 228
26.6 Worked problems (iii) on trigonometric equations 229
26.7 Worked problems (iv) on trigonometric equations 229

27 Compound angles 231
27.1 Compound angle formulae 231
27.2 Conversion of $a\sin\omega t + b\cos\omega t$ into $R\sin(\omega t + \alpha)$ 233
27.3 Double angles 236
27.4 Changing products of sines and cosines into sums or differences 238
27.5 Changing sums or differences of sines and cosines into products 239

Revision Test 7 241

Multiple choice questions on Chapters 18–27 242

试读结束：需要全本请在线购买： www.ertongbook.com

Section 4 Graphs 247

28 Straight line graphs 249
28.1 Introduction to graphs 249
28.2 The straight line graph 249
28.3 Practical problems involving straight line graphs 255

29 Reduction of non-linear laws to linear form 261
29.1 Determination of law 261
29.2 Determination of law involving logarithms 264

30 Graphs with logarithmic scales 269
30.1 Logarithmic scales 269
30.2 Graphs of the form $y = ax^n$ 269
30.3 Graphs of the form $y = ab^x$ 272
30.4 Graphs of the form $y = ae^{kx}$ 273

31 Graphical solution of equations 276
31.1 Graphical solution of simultaneous equations 276
31.2 Graphical solution of quadratic equations 277
31.3 Graphical solution of linear and quadratic equations simultaneously 281
31.4 Graphical solution of cubic equations 282

32 Functions and their curves 284
32.1 Standard curves 284
32.2 Simple transformations 286
32.3 Periodic functions 291
32.4 Continuous and discontinuous functions 291
32.5 Even and odd functions 291
32.6 Inverse functions 293

Revision Test 8 297

Section 5 Vectors 299

33 Vectors 301
33.1 Introduction 301
33.2 Vector addition 301
33.3 Resolution of vectors 302
33.4 Vector subtraction 305

34 Combination of waveforms 307
34.1 Combination of two periodic functions 307
34.2 Plotting periodic functions 307
34.3 Determining resultant phasors by calculation 308

Section 6 Complex Numbers 311

35 Complex numbers 313
35.1 Cartesian complex numbers 313
35.2 The Argand diagram 314
35.3 Addition and subtraction of complex numbers 314
35.4 Multiplication and division of complex numbers 315
35.5 Complex equations 317
35.6 The polar form of a complex number 318
35.7 Multiplication and division in polar form 320
35.8 Applications of complex numbers 321

36 De Moivre's theorem 325
36.1 Introduction 325
36.2 Powers of complex numbers 325
36.3 Roots of complex numbers 326

Revision Test 9 329

Section 7 Statistics 331

37 Presentation of statistical data 333
37.1 Some statistical terminology 333
37.2 Presentation of ungrouped data 334
37.3 Presentation of grouped data 338

38 Measures of central tendency and dispersion 345
38.1 Measures of central tendency 345
38.2 Mean, median and mode for discrete data 345
38.3 Mean, median and mode for grouped data 346
38.4 Standard deviation 348
38.5 Quartiles, deciles and percentiles 350

39 Probability 352
39.1 Introduction to probability 352
39.2 Laws of probability 353
39.3 Worked problems on probability 353
39.4 Further worked problems on probability 355

39.5 Permutations and combinations 357

Revision Test 10 359

40 The binomial and Poisson distribution 360
40.1 The binomial distribution 360
40.2 The Poisson distribution 363

41 The normal distribution 366
41.1 Introduction to the normal distribution 366
41.2 Testing for a normal distribution 371

Revision Test 11 374

Multiple choice questions on Chapters 28–41 375

Section 8 Differential Calculus 381

42 Introduction to differentiation 383
42.1 Introduction to calculus 383
42.2 Functional notation 383
42.3 The gradient of a curve 384
42.4 Differentiation from first principles 385
42.5 Differentiation of $y = ax^n$ by the general rule 387
42.6 Differentiation of sine and cosine functions 388
42.7 Differentiation of e^{ax} and $\ln ax$ 390

43 Methods of differentiation 392
43.1 Differentiation of common functions 392
43.2 Differentiation of a product 394
43.3 Differentiation of a quotient 395
43.4 Function of a function 397
43.5 Successive differentiation 398

44 Some applications of differentiation 400
44.1 Rates of change 400
44.2 Velocity and acceleration 401
44.3 Turning points 404
44.4 Practical problems involving maximum and minimum values 408
44.5 Tangents and normals 411
44.6 Small changes 412

Revision Test 12 415

45 Differentiation of parametric equations 416
45.1 Introduction to parametric equations 416
45.2 Some common parametric equations 416
45.3 Differentiation in parameters 417
45.4 Further worked problems on differentiation of parametric equations 418

46 Differentiation of implicit functions 421
46.1 Implicit functions 421
46.2 Differentiating implicit functions 421
46.3 Differentiating implicit functions containing products and quotients 422
46.4 Further implicit differentiation 423

47 Logarithmic differentiation 426
47.1 Introduction to logarithmic differentiation 426
47.2 Laws of logarithms 426
47.3 Differentiation of logarithmic functions 426
47.4 Differentiation of $[f(x)]^x$ 429

Revision Test 13 431

Section 9 Integral Calculus 433

48 Standard integration 435
48.1 The process of integration 435
48.2 The general solution of integrals of the form ax^n 435
48.3 Standard integrals 436
48.4 Definite integrals 439

49 Integration using algebraic substitutions 442
49.1 Introduction 442
49.2 Algebraic substitutions 442
49.3 Worked problems on integration using algebraic substitutions 442

49.4 Further worked problems on integration using algebraic substitutions 444
49.5 Change of limits 444

50 Integration using trigonometric substitutions 447
50.1 Introduction 447
50.2 Worked problems on integration of $\sin^2 x$, $\cos^2 x$, $\tan^2 x$ and $\cot^2 x$ 447
50.3 Worked problems on powers of sines and cosines 449
50.4 Worked problems on integration of products of sines and cosines 450
50.5 Worked problems on integration using the $\sin\theta$ substitution 451
50.6 Worked problems on integration using the $\tan\theta$ substitution 453

Revision Test 14 454

51 Integration using partial fractions 455
51.1 Introduction 455
51.2 Worked problems on integration using partial fractions with linear factors 455
51.3 Worked problems on integration using partial fractions with repeated linear factors 456
51.4 Worked problems on integration using partial fractions with quadratic factors 457

52 The $t = \tan\frac{\theta}{2}$ substitution 460
52.1 Introduction 460
52.2 Worked problems on the $t = \tan\frac{\theta}{2}$ substitution 460
52.3 Further worked problems on the $t = \tan\frac{\theta}{2}$ substitution 462

53 Integration by parts 464
53.1 Introduction 464
53.2 Worked problems on integration by parts 464
53.3 Further worked problems on integration by parts 466

54 Numerical integration 469
54.1 Introduction 469
54.2 The trapezoidal rule 469
54.3 The mid-ordinate rule 471
54.4 Simpson's rule 473

Revision Test 15 477

55 Areas under and between curves 478
55.1 Area under a curve 478
55.2 Worked problems on the area under a curve 479
55.3 Further worked problems on the area under a curve 482
55.4 The area between curves 484

56 Mean and root mean square values 487
56.1 Mean or average values 487
56.2 Root mean square values 489

57 Volumes of solids of revolution 491
57.1 Introduction 491
57.2 Worked problems on volumes of solids of revolution 492
57.3 Further worked problems on volumes of solids of revolution 493

58 Centroids of simple shapes 496
58.1 Centroids 496
58.2 The first moment of area 496
58.3 Centroid of area between a curve and the x-axis 496
58.4 Centroid of area between a curve and the y-axis 497
58.5 Worked problems on centroids of simple shapes 497
58.6 Further worked problems on centroids of simple shapes 498
58.7 Theorem of Pappus 501

59 Second moments of area 505
59.1 Second moments of area and radius of gyration 505
59.2 Second moment of area of regular sections 505
59.3 Parallel axis theorem 506
59.4 Perpendicular axis theorem 506
59.5 Summary of derived results 506
59.6 Worked problems on second moments of area of regular sections 507
59.7 Worked problems on second moments of area of composite areas 510

Revision Test 16 512

Section 10 Further Number and Algebra 513

60 Boolean algebra and logic circuits 515
- 60.1 Boolean algebra and switching circuits 515
- 60.2 Simplifying Boolean expressions 520
- 60.3 Laws and rules of Boolean algebra 520
- 60.4 De Morgan's laws 522
- 60.5 Karnaugh maps 523
- 60.6 Logic circuits 528
- 60.7 Universal logic gates 532

61 The theory of matrices and determinants 536
- 61.1 Matrix notation 536
- 61.2 Addition, subtraction and multiplication of matrices 536
- 61.3 The unit matrix 540
- 61.4 The determinant of a 2 by 2 matrix 540
- 61.5 The inverse or reciprocal of a 2 by 2 matrix 541
- 61.6 The determinant of a 3 by 3 matrix 542
- 61.7 The inverse or reciprocal of a 3 by 3 matrix 544

62 The solution of simultaneous equations by matrices and determinants 546
- 62.1 Solution of simultaneous equations by matrices 546
- 62.2 Solution of simultaneous equations by determinants 548
- 62.3 Solution of simultaneous equations using Cramers rule 552

Revision Test 17 553

Section 11 Differential Equations 555

63 Introduction to differential equations 557
- 63.1 Family of curves 557
- 63.2 Differential equations 558
- 63.3 The solution of equations of the form $\frac{dy}{dx} = f(x)$ 558
- 63.4 The solution of equations of the form $\frac{dy}{dx} = f(y)$ 560
- 63.5 The solution of equations of the form $\frac{dy}{dx} = f(x) \cdot f(y)$ 562

Revision Test 18 565

Multiple choice questions on Chapters 42–63 566

Answers to multiple choice questions 570

Index 571

Section 1

Number and Algebra

Section 1

Number and Algebra

试读结束：需要全本请在线购买： www.ertongbook.com