Contents

Preface xvii
Acknowledgements xix
Part 1 Engineering Mathematics and Science

1.1 Engineering mathematics 3
1.1.1 The Greek alphabet 3
1.1.2 Mathematical symbols 4
1.1.3 Units: SI 5
1.1.4 Units: not SI 7
1.1.5 Notes on writing symbols 8
1.1.6 Decimal multiples of units 8
1.1.7 Conversion factors for units 9
1.1.8 Conversion table: millimetres to inches 11
1.1.9 Conversion table: minutes of arc to degrees 12
1.1.10 Conversion table: fractions to decimals 13
1.1.11 Conversion table: temperature, $-50°$ to $210°$ 14
1.1.12 Conversion table: temperature, $215°$ to $3000°$ 16
1.1.13 Conversion tables: low pressure 18
1.1.14 Conversion table: high pressure 19
1.1.15 Conversion table: stress, tonf/in^2 to N/mm^2 (MN/m^2) 21
1.1.16 Conversion table: stress, kgf/mm^2 to N/mm^2 (MN/m^2) 22
1.1.17 Conversion table: degrees to radians 23
1.1.18 Preferred numbers 24
1.1.19 Use of a calculator 24
1.1.20 Mensuration 27
1.1.21 Powers, roots and reciprocals 34
1.1.22 Progressions 39
1.1.23 Trigonometric formulae 40
1.1.24 Circles: some definitions and properties 42
1.1.25 Circles: areas and circumferences 44

1.1.26 Coordinate systems 46
1.1.27 Statistics: an introduction 49

1.2 *Engineering science* 54
1.2.1 Weight and mass 54
1.2.2 Heat 54
1.2.3 Sound 56
1.2.4 Electrical formulae 56
1.2.5 Stress and strain 60
1.2.6 Stress in thin cylindrical shells 63
1.2.7 Beams: shearing force and bending moment diagrams 65
1.2.8 Beams: general formulae for simple bending 66
1.2.9 Section formulae 66
1.2.10 Static friction: dry 68
1.2.11 Levers 69
1.2.12 Formulae relating to rotary motion 70

Part 2 Engineering Design Data
2.1 *Screwed fastenings* 73
2.1.1 Drawing proportions 73
2.1.2 Alternative screw heads 75
2.1.3 Alternative screw points 76
2.1.4 Hexagon socket cap head screw 76
2.1.5 Application of screwed fasteners 77
2.1.6 Acme thread form 77
2.1.7 Square thread form 78
2.1.8 Buttress thread form 78
2.1.9 V-thread form 79
2.1.10 ISO metric and ISO unified thread forms 79
2.1.11 ISO metric black hexagon bolts and nuts, coarse thread series 80
2.1.12 ISO metric precision hexagon bolts and nuts, coarse thread series 81
2.1.13 ISO metric precision hexagon bolts and nuts, fine thread series 82
2.1.14 ISO metric hexagon socket head screws 83
2.1.15 ISO unified precision internal screw threads, coarse series 85
2.1.16 ISO unified precision external screw threads, coarse series 87

2.1.17	ISO unified precision internal screw threads, fine series	89
2.1.18	ISO unified precision external screw threads, fine series	90
2.1.19	ISO metric screw threads, miniature series	91
2.1.20	Basis for standard metric thread lengths	92
2.1.21	Strength grade designation of metric steel bolts and screws	93
2.1.22	Strength grade designation of metric steel nuts	94
2.1.23	Recommended metric bolt and nut combinations	94
2.1.24	Mechanical properties of metric steel bolts and nuts	95
2.1.25	ISO pipe thread forms	100
2.1.26	ISO pipe threads, parallel: basic sizes	102
2.1.27	ISO pipe threads, tapered: basic sizes	104
2.1.28	BA thread form	106
2.1.29	BA internal and external screw threads	107
2.1.30	ISO metric screw threads: constant pitch series	109
2.1.31	Plain washers, bright: metric series	115
2.1.32	Plain washers, black: metric series	116
2.1.33	Friction locking devices	118
2.1.34	Positive locking devices	120
2.1.35	Single coil square section spring washers: metric series, type A	122
2.1.36	Single coil rectangular section spring washers: metric series, types B and BP	124
2.1.37	Double coil rectangular section spring washers: metric series, type D	127
2.1.38	Toothed lock washers, metric	128
2.1.39	Serrated lock washers, metric	131
2.1.40	ISO metric crinkle washers: general engineering	134
2.1.41	Wire thread inserts	135
2.1.42	T-slot profiles	136
2.1.43	Dimensions of T-bolts and T-nuts	138
2.1.44	Dimensions for tenons for T-slots	142
2.2	*Riveted joints*	144
2.2.1	Typical rivet heads and shanks	144
2.2.2	Typical riveted lap joints	145
2.2.3	Typical riveted butt joints	146
2.2.4	Proportions for hole diameter and rivet length	147
2.2.5	Cold forged snap head rivets	148

2.2.6	Hot forged snap head rivets	149
2.2.7	Tentative range of nominal lengths associated with shank diameters	150
2.2.8	Pop rivets	151
2.3	*Self-secured joints*	159
2.3.1	Self-secured joints	159
2.3.2	Allowances for self-secured joints	161
2.4	*Miscellaneous fasteners*	163
2.4.1	Taper pins, unhardened: metric series	164
2.4.2	Circlips, external: metric series	165
2.4.3	Circlips, internal: metric series	168
2.5	*Power transmission: gears*	171
2.5.1	Some typical gear drives	171
2.5.2	Simple spur gear trains	174
2.5.3	Compound spur gear train	176
2.5.4	The involute curve	178
2.5.5	Basic gear tooth geometry	179
2.5.6	Gear tooth pitch	184
2.5.7	Gear tooth height	185
2.5.8	Standard gear tooth elements (inches)	186
2.5.9	Fine pitch gear tooth elements (inches)	187
2.5.10	Standard stub gear tooth elements (inches)	188
2.5.11	Standard gear tooth elements, metric	189
2.5.12	Letter symbols for gear dimensions and calculations	191
2.5.13	Basic spur gear calculations	193
2.5.14	Basic helical gear equations	194
2.5.15	Miscellaneous gear equations	194
2.5.16	Straight bevel gear nomenclature	196
2.5.17	Worm and worm wheel nomenclature	197
2.6	*Power transmission: belt drives*	198
2.6.1	Simple flat belt drives	198
2.6.2	Compound flat belt drive	200
2.6.3	Typical belt tensioning devices	201
2.6.4	Typical V-belt drive applications	202
2.6.5	FO®-Z heavy-duty cogged raw edge V-belts	206
2.6.6	ULTRAFLEX ® narrow-section wrapped V-belts	208

2.6.7	MULTIFLEX ® classical-section wrapped V-belts	210
2.6.8	V-belt pulleys for FO®-Z and ULTRAFLEX ® belts	212
2.6.9	V-belt pulleys for MULTIFLEX ® belts	214
2.6.10	Deep-groove pulleys	216
2.6.11	SYNCHROBELT ® HTD synchronous (toothed) belts	220
2.6.12	SYNCHROBELT ® HTD synchronous (toothed) belts: tooth profiles	222
2.6.13	Synchronous (toothed) belts: length measurement	226
2.6.14	SYNCHROBELT® HTD toothed pulleys: preferred sizes	227
2.7	*Power transmission: shafts*	231
2.7.1	Square and rectangular parallel keys, metric series	231
2.7.2	Dimensions and tolerances for square and rectangular parallel keys	234
2.7.3	Square and rectangular taper keys, metric series	236
2.7.4	Dimensions and tolerances for square and rectangular taper keys	239
2.7.5	Woodruff keys and keyways	242
2.7.6	Dimensions and tolerances for Woodruff keys	244
2.7.7	Shaft end types: general relationships	246
2.7.8	Dimensions and tolerances of cylindrical shaft ends, long and short series	247
2.7.9	Dimensions of conical shaft ends with parallel keys, long series	250
2.7.10	Dimensions of conical shaft ends with diameters above 220 mm with the keyway parallel to the shaft surface, long series	253
2.7.11	Dimensions of conical shaft ends with parallel keys, short series	254
2.7.12	Transmissible torque values	256
2.7.13	Straight sided splines for cylindrical shafts, metric	258
2.7.14	Self-holding Morse and metric 5% tapers	261
2.7.15	General dimensions of self-holding Morse and metric 5% taper shanks and sockets	262
2.7.16	Tolerances on self-holding Morse taper shanks and sockets	264

2.7.17	Spindle noses with self-release 7/24 tapers	265
2.7.18	Self-release 7/24 taper shanks	266
Part 3	**Engineering Materials**	
3.1	*Mechanical properties*	271
3.1.1	Tensile strength	271
3.1.2	Compressive strength	271
3.1.3	Shear strength	271
3.1.4	Toughness: impact resistance	272
3.1.5	Elasticity	272
3.1.6	Plasticity	272
3.1.7	Ductility	273
3.1.8	Malleability	273
3.1.9	Hardness	273
3.1.10	Tensile test	274
3.1.11	Interpretation of a tensile test: material showing a yield point	275
3.1.12	Interpretation of a tensile test: proof stress	277
3.1.13	Interpretation of a tensile test: secant modulus	277
3.1.14	Impact testing for toughness: Izod test	278
3.1.15	Impact testing for toughness: Charpy test	278
3.1.16	Interpretation of impact test results	279
3.1.17	Brinell hardness test	280
3.1.18	Vickers hardness test	280
3.1.19	Rockwell hardness test	281
3.1.20	Rockwell superficial hardness test	282
3.1.21	Comparative hardness scales	283
3.2	*Ferrous metals and alloys*	285
3.2.1	Ferrous metals: plain carbon steels	285
3.2.2	Properties and uses of some plain carbon steels	287
3.2.3	Effect of carbon content on the composition, properties and uses of plain carbon steels	289
3.2.4	Ferrous metals: alloying elements	289
3.2.5	Low alloy constructional steels	292
3.2.6	Alloy tool and die steels	294
3.2.7	Stainless and heat resisting steels	296
3.2.8	Interpretation of BS 970: *Wrought steels*	298
3.2.9	Grey cast irons	304
3.2.10	Malleable cast irons	307
3.2.11	Spheroidal graphite cast irons	309
3.2.12	Alloy cast irons	312

3.2.13	Composition, properties and uses of some cast irons	313
3.3	*Non-ferrous metals and alloys*	315
3.3.1	Non-ferrous metals and alloys	315
3.3.2	High copper content alloys	316
3.3.3	Wrought copper and copper alloys: condition code	317
3.3.4	Copper sheet, strip and foil	318
3.3.5	Brass sheet, strip and foil: binary alloys of copper and zinc	320
3.3.6	Brass sheet, strip and foil: special alloys and leaded brasses	324
3.3.7	Phosphor bronze sheet, strip and foil	326
3.3.8	Aluminium bronze sheet, strip and foil	329
3.3.9	Copper-nickel (cupro-nickel) sheet, strip and foil	330
3.3.10	Nickel-silver sheet, strip and foil	332
3.3.11	Miscellaneous wrought copper alloys	334
3.3.12	Copper alloys for casting: group A	338
3.3.13	Copper alloys for casting: group B	342
3.3.14	Copper alloys for casting: group C	346
3.3.15	Copper alloys for casting: typical properties and hardness values	350
3.3.16	Wrought aluminium and aluminium alloys: condition code	355
3.3.17	Unalloyed aluminium plate, sheet and strip	356
3.3.18	Aluminium alloy plate, sheet and strip: non-heat-treatable	358
3.3.19	Aluminium alloy plate, sheet and strip: heat-treatable	361
3.3.20	Aluminium and aluminium alloy bars, extruded tube and sections for general engineering: non-heat-treatable	364
3.3.21	Aluminium alloy bars, extruded tube and sections for general engineering: heat-treatable	366
3.3.22	Cast aluminium alloys: condition code	369
3.3.23	Aluminium alloy castings, group A: general purpose	370
3.3.24	Aluminium alloy castings, group B: special purpose	371
3.3.25	Aluminium alloy castings, group C: special purpose and of limited application	372

3.3.26	**Aluminium alloy castings: mechanical properties**	374
3.3.27	Soft solders	376
3.3.28	Typical uses of soft solders	378
3.4	*Metallic material sizes*	380
3.4.1	Metallic material sizes: introduction to BS 6722 : 1986	380
3.4.2	Recommended diameters of wires, metric	381
3.4.3	Recommended dimensions for bar and flat products	382
3.4.4	Recommended widths and lengths of flat products	383
3.4.5	Mass of metric round and square bars	384
3.4.6	Hexagon bar sizes for screwed fasteners, metric	386
3.4.7	Gauge sizes and equivalents	387
3.5	*Polymeric (plastic) materials*	389
3.5.1	Polymeric materials (plastics)	389
3.5.2	Some important thermosetting polymers	392
3.5.3	Some important themoplastic polymers	394
Part 4	**Computer Aided Engineering**	
4.1	*Computer numerical control*	399
4.1.1	Background to computer numerical control	399
4.1.2	Typical applications of computer numerical control	401
4.1.3	Advantages and limitations of computer numerical control	401
4.1.4	Axes of control for machine tools	403
4.1.5	Positioning control	404
4.1.6	Control systems	405
4.1.7	Program terminology and formats	407
4.1.8	Coded information	409
4.1.9	Data input	414
4.1.10	Tool length offsets: milling	415
4.1.11	Cutter diameter compensation: milling	415
4.1.12	Programming techniques: milling	418
4.1.13	Programming example: milling	420
4.1.14	Tool offsets: lathe	423
4.1.15	Tool nose radius compensation: lathe	425
4.1.16	Programming techniques: lathe	426
4.1.17	Programming example: lathe	428

4.1.18	Glossary of terms	432
4.2	*Computer aided design*	435
4.2.1	An introduction to computer aided design	435
4.2.2	CAD system hardware	436
4.2.3	CAD system software	441
4.2.4	Computer aided design and manufacture	442
4.2.5	Advantages and limitations of computer aided design	443
4.3	*Industrial robots*	444
4.3.1	An introduction to robotics	444
4.3.2	Robot control	445
4.3.3	Robot arm geometry	445
Part 5	**Cutting Tools**	
5.1	*Twist drills, reamers, countersinking and counterboring cutters*	452
5.1.1	Twist drill sizes, metric	452
5.1.2	Twist drills: equivalent sizes	463
5.1.3	BA threads: tapping and clearance drills	464
5.1.4	ISO metric tapping and clearance drills, coarse thread series	465
5.1.5	ISO metric tapping and clearance drills, fine thread series	466
5.1.6	ISO unified tapping and clearance drills, coarse thread series	466
5.1.7	ISO unified tapping and clearance drills, fine thread series	467
5.1.8	ISO metric tapping and clearance drills, miniature series	468
5.1.9	Hand reamers	468
5.1.10	Long flute machine reamers	470
5.1.11	Machine chucking reamers with Morse taper shanks	472
5.1.12	Shell reamers with taper bore	473
5.1.13	Hand taper pin reamer	478
5.1.14	Counterbores with parallel shanks and integral pilots	480
5.1.15	Counterbores with Morse taper shanks and detachable pilots	482
5.1.16	Detachable pilots for counterbores	485

5.1.17	Countersinks with parallel shanks	487
5.1.18	Countersinks with Morse taper shanks	488
5.2.	*Single point cutting tools*	490
5.2.1	Single point cutting tools: butt welded high speed steel	490
5.2.2	Tool bits: ground high speed steel	497
5.3	*Milling cutters*	498
5.3.1	Cylindrical cutters	498
5.3.2	High helix cylindrical cutters	500
5.3.3	Side and face cutters	501
5.3.4	Staggered tooth side and face cutters	502
5.3.5	Slotting cutters	503
5.3.6	Metal slitting saws without side chip clearance: fine teeth	504
5.3.7	Metal slitting saws without side chip clearance: coarse teeth	506
5.3.8	Metal slitting saws with side chip clearance	508
5.3.9	Convex milling cutters	510
5.3.10	Concave milling cutters	510
5.3.11	Corner rounding concave milling cutters	512
5.3.12	Double equal angle milling cutters	513
5.3.13	T-slot cutters with Morse taper shanks	514
5.3.14	Shell end mills	515
5.3.15	Arbors for shell end mills	517
5.3.16	Screwed shank end mills: normal series	520
5.3.17	Screwed shank slot drills: normal series	523
5.3.18	Screwed shank slot drills, ball nosed: normal series	526
5.4	*Bonded abrasives*	529
5.4.1	Example of the complete marking of an abrasive wheel	529
5.4.2	Classification of wheel and product shapes by type numbers	530
5.4.3	Maximum permissible peripheral speeds of abrasive wheels	533
5.5	*Carbide cutting tool materials*	538
5.5.1	Coromant carbide grades for turning	538

5.5.2 Coromant carbide turning tools: selecting the toolholder system 540
5.5.3 Coromant carbide turning tools: selecting the insert 543
5.5.4 Coromant carbide turning tools: comparison of insert types 544
5.5.5 Coromant carbide turning tools: selecting the insert size 548
5.5.6 Coromant carbide turning tools: selecting the nose radius and feed 550
5.5.7 Coromant carbide turning tools: nominal cutting speeds and feeds 552
5.5.8 Coromant carbide turning tools: insert wear and tool life 554
5.5.9 Coromant carbide grades for milling 558
5.5.10 Coromant carbide milling cutters: nominal cutting speed values 560
5.5.11 Coromant carbide milling cutters: machining economy and cutting data 565
5.5.12 Coromant carbide grades for drilling 566
5.5.13 Coromant carbide drill types for short holes 568
5.5.14 Coromant carbide drills: cutting data 570
5.5.15 Coromant carbide drills: designations and formulae 574
5.5.16 Coromant carbide drills: regrinding 580

Appendix 1 British Standards: orders and information 583
Appendix 2 Public libraries (UK) holding sets of British Standards 586
Appendix 3 Contributing companies 591
Index 592