

Contents

1	Introduction	1
	<i>Robin J. Wilson</i>	
1.1	Graphs	1
1.2	Adjacency and incidence	3
1.3	Paths and cycles	4
1.4	New graphs from old	5
1.5	Examples of graphs	7
1.6	Planar graphs	9
1.7	Colouring graphs	11
1.8	The efficiency of algorithms	11
1.9	And finally ...	12
	References	12
2	Enumeration	13
	<i>Ronald C. Read</i>	
2.1	Introduction	13
2.2	Labelled graphs and generating functions	13
2.3	Necklaces	15
2.4	Pólya's Enumeration Theorem	16
2.5	Chemical enumeration	19
2.6	The enumeration of graphs	23
2.7	Connected graphs	26
2.8	Trees and rooted trees	28
2.9	Other kinds of graphs	30
2.10	Unsolved problems	31
	References	32
3	Number Theory	34
	<i>Roger Cook</i>	
3.1	Introduction	34
3.2	Multiplicative functions	35
3.3	The Möbius function	36
3.4	Euler's function	38
3.5	Pólya's Enumeration Theorem	39
3.6	Eulerian graphs and tournaments	40
3.7	Finite fields and Paley graphs	42
3.8	Quadratic residue tournaments	44
3.9	Hadamard matrices and designs	45
3.10	Ramanujan graphs	46
3.11	Negative Pell equations	48
	References	49

4	Partial Orders	52
	<i>Graham Brightwell</i>	
4.1	Introduction	52
4.2	Preliminaries	52
4.3	Dilworth's Theorem	55
4.4	Comparability graphs	58
4.5	Covering graphs and diagrams	60
4.6	Schnyder's Theorem	61
4.7	The incidence order	66
	References	67
5	First-order Logic	70
	<i>Peter J. Cameron</i>	
5.1	Introduction	70
5.2	First-order logic	70
5.3	First-order properties of graphs	73
5.4	Applications of compactness	75
5.5	The random graph	77
5.6	Homogeneous graphs	78
5.7	$\aleph_0$ -categorical graphs	80
5.8	Sparse graphs	81
	References	84
6	Linear Algebra	86
	<i>Peter Rowlinson</i>	
6.1	Introduction	86
6.2	Graph spectra	87
6.3	Distance-regular graphs	89
6.4	Other algebraic invariants	92
6.5	Eigenvalues and star partitions	95
	References	98
7	Matroids	100
	<i>James Oxley</i>	
7.1	Introduction	100
7.2	Definitions and examples	101
7.3	Basic matroid operations	103
7.4	Connectivity	106
7.5	Wheels and whirls	108
7.6	Minimally 3-connected graphs and matroids	109
7.7	Excluded minors	111
7.8	Infinite antichains	113
7.9	Conclusion	114
	References	114

8	Codes	116
	<i>Robert T. Curtis and Tony R. Morris</i>	
8.1	Introduction	116
8.2	Self-dual doubly-even codes	116
8.3	Invariant theory	117
8.4	Constructing binary codes from graphs	119
8.5	How many codes arise like this?	121
8.6	Graphs with the required properties	122
8.7	Counting tetrads	127
	References	127
9	Groups	128
	<i>Peter J. Cameron</i>	
9.1	Introduction	128
9.2	An example: the Petersen graph	128
9.3	Three kinds of groups	129
9.4	Universal classes	130
9.5	Bounds	132
9.6	Random graphs	133
9.7	Vertex-transitive graphs	134
9.8	Distance-transitive graphs	135
9.9	Local structure	137
9.10	Computational aspects	138
	References	139
10	Geometry	141
	<i>Edward R. Scheinerman</i>	
10.1	Introduction	141
10.2	Dimension 0: discrete sets	142
10.3	Dimension 1: interval graphs	144
10.4	Dimension 1 and a little: trees and circles	147
10.5	Dimensions 2 and higher	148
10.6	Counting methods via real algebraic geometry	150
	References	153
11	Topology	155
	<i>Lowell W. Beineke</i>	
11.1	Introduction	155
11.2	Planar graphs	156
11.3	Thickness	158
11.4	Crossing numbers	160
11.5	Orientable surfaces and rotation systems	164
11.6	Genus and chromatic numbers	166
11.7	Non-orientable surfaces	168
11.8	Kuratowski-type theorems	171
	References	173

12	Knots	176
	<i>Dominic Welsh</i>	
12.1	Introduction	176
12.2	Basic concepts	177
12.3	Tait colourings	179
12.4	Classifying knots	181
12.5	Braids and the Seifert graph	182
12.6	The Jones and Kauffman bracket polynomials	184
12.7	Bivariate polynomials	187
12.8	The Tait conjectures	188
12.9	Two applications	190
	References	192
13	Probability	194
	<i>Colin McDiarmid</i>	
13.1	Introduction	194
13.2	Random graphs: usual behaviour	194
13.3	Random graphs: deterministic results	198
13.4	The Lovász Local Lemma	199
13.5	Deterministic graphs: random methods	201
13.6	Concentration of measure and isoperimetric inequalities	204
	References	206
14	Statistics	208
	<i>Peter Wild</i>	
14.1	Introduction	208
14.2	Experimental design	209
14.3	A -optimality and closed walks	215
14.4	Bounds	218
14.5	Spanning trees and D -optimality	221
14.6	Line graphs and E -optimality	222
14.7	Row-column designs	224
14.8	Conclusion	225
	References	225
15	Computing	227
	<i>Robin Whitty</i>	
15.1	Introduction	227
15.2	Languages	228
15.3	Grammars	228
15.4	Finite automata	231
15.5	Flowgraphs	235
15.6	Program analysis	239
	References	244

16 Artificial Neural Networks	247
<i>Martin Anthony</i>	
16.1 Introduction	247
16.2 Artificial neural networks	248
16.3 Boltzmann machines	248
16.4 Optimization with Boltzmann machines	250
16.5 Feedforward networks	252
16.6 Supervised learning in feedforward networks	253
References	259
17 International Finance	261
<i>Norman Biggs</i>	
17.1 Introduction	261
17.2 Exchange dealing then and now	262
17.3 Exchange rate networks	264
17.4 Some classical theory	266
17.5 The export and import points	268
17.6 Potential theory	271
17.7 Determination of exchange rates by cash flows	273
17.8 Application to a tournament ranking problem	277
17.9 Mechanisms linking exchange rates and trade	277
References	278
Notes on Contributors	280
Index	285