

Contents

	Preface	v
	INTRODUCTION	1
1	GRAPHS	11
	Abstract graphs and realizations	12
	*Kirchhoff's laws	18
	Maximal trees and the cyclomatic number	20
	Chains and cycles on an oriented graph	25
	*Planar graphs	32
	*Appendix on Kirchhoff's equations	45
2	CLOSED SURFACES	49
	Closed surfaces and orientability	51
	Polygonal representation of a closed surface	57
	Transformation of closed surfaces to standard form	62
	Euler characteristics	69
	*Minimal triangulations	76
3	SIMPLICIAL COMPLEXES	85
	Simplexes	86
	Ordered simplexes and oriented simplexes	93

3	SIMPLICIAL COMPLEXES (continued)	
	Simplicial complexes	95
	Abstract simplicial complexes and realizations	99
	Triangulations and diagrams of simplicial complexes	102
	Stars joins and links	108
	Collapsing	113
	*Appendix on orientation	118
4	HOMOLOGY GROUPS	127
	Chain groups and boundary homomorphisms	127
	Homology groups	133
	Relative homology groups	145
	Three homomorphisms	155
	*Appendix on chain complexes	159
5	THE QUESTION OF INVARIANCE	163
	Invariance under stellar subdivision	164
	*Triangulations simplicial approximation and topological invariance	171
	*Appendix on barycentric subdivision	174
6	SOME GENERAL THEOREMS	177
	The homology sequence of a pair	178
	The excision theorem	183
	Collapsing revisited	185
	Homology groups of closed surfaces	191
	The Euler characteristic	198
7	TWO MORE GENERAL THEOREMS	201
	The Mayer-Vietoris sequence	202
	*The homology sequence of a triple	211
8	HOMOLOGY MODULO 2	217

9	GRAPHS IN SURFACES	229
	Regular neighbourhoods	232
	Surfaces	238
	Lefschetz duality	244
	*A three-dimensional situation	248
	Separating surfaces by graphs	252
	Representation of homology elements by simple closed polygons	256
	Orientation preserving and reversing loops	259
	A generalization of Euler's formula	264
	*Brussels sprouts	271
	 APPENDIX: ABELIAN GROUPS	 277
	Basic definitions	277
	Finitely generated (f.g.) and free abelian groups	280
	Quotient groups	282
	Exact sequences	284
	Direct sums and splitting	286
	Presentations	290
	Rank of a f.g. abelian group	299
	 References	 309
	List of Notation	313
	Index	319