

Contents

CHAPTER 0. SETS AND NUMBERS

0.1 Rudiments of Logic	1
0.2 Fundamentals of Set Description	5
0.3 Set Inclusion and Equality	5
0.4 An Axiom System for Set Theory	6
0.5 Unions and Intersections	6
0.6 Set Difference	7
0.7 Integers and Induction	7
0.8 Simple Cartesian Products	11
0.9 Relations	11
0.10 Functions	12
0.11 Sequences	14
0.12 Indexing Sets	15
0.13 Important Formulas	16
0.14 Inverse Functions	16
0.15 More Important Formulas	17
0.16 Partitions	18
0.17 Equivalence Relations, Partitions and Functions	18
0.18 General Cartesian Products	19
0.19 The Sixth Axiom (Axiom of Choice)	20
0.20 Well-Orders and Zorn	21
0.21 Yet More Important Formulas	22
0.22 Cardinality	22

CHAPTER 1. METRIC AND TOPOLOGICAL SPACES

1.1 Metrics and Topologies	31
1.2 Time out for Notation	33
1.3 Metrics Generate Topologies	35
1.4 Continuous Functions	36
1.5 Subspaces	39
1.6 Comparable Topologies	39

CHAPTER 2. FROM OLD TO NEW SPACES

2.1 Product Spaces	47
2.2 Product Metrics and Topologies	51

2.3 Quotient Spaces	53
2.4 Applications (Möbius Band, Klein Bottle, Torus, Projective Plane, etc.)	55

CHAPTER 3. VERY SPECIAL SPACES

3.1 Compact Spaces	67
3.2 Compactification (One-Point Only)	73
3.3 Complete Metric Spaces (Baire-Category, Banach Contraction Theorem and Applications of Roots of $y = h(x)$ to Systems of Linear Equations	75
3.4 Connected and Arcwise Connected Spaces	80

CHAPTER 4. FUNCTION SPACES

4.1 Function Space Topologies	89
4.2 Completeness and Compactness (Ascoli-Arzela Theorem, Picard's Theorem, Peano's Theorem)	92
4.3 Approximation (Bernstein's polynomials, Stone-Weierstrass Approximation)	100
4.4 Function-Space Functions	103

CHAPTER 5. TOPOLOGICAL GROUPS

5.1 Elementary Structures	114
5.2 Topological Isomorphism Theorems	121
5.3 Quotient Group Recognition	123
5.4 Morphism Groups (Topological and Transformation Groups)	124

CHAPTER 6. SPECIAL GROUPS

6.1 Preliminaries	131
6.2 Groups of Matrices	134
6.3 Groups of Isometries	135
6.4 Relativity and Lorentz Transformations	140

CHAPTER 7. NORMALITY AND PARACOMPACTNESS

7.1 Normal Spaces (Urysohn's Lemma)	147
7.2 Paracompact Spaces (Partitions of Unity with and Application to Embedding of Manifolds in Euclidean Spaces)	151

CHAPTER 8. THE FUNDAMENTAL GROUP

8.1 Description of $\Pi_1(X, b)$	167
8.2 Elementary Facts about $\Pi_1(X, b)$	173
8.3 Simplicial Complexes	175
8.4 Barycentric Subdivision	179
8.5 The Simplicial Approximation	181
8.6 The Fundamental Group of Polytopes	183
8.7 Graphs and Trees	187

APPENDIX A. SOME INEQUALITIES	193
APPENDIX B. BINOMIAL EQUALITIES	195
LIST OF SYMBOLS	197
INDEX	199

We assume that the reader has a good grasp of the fundamentals of Logic and Set Theory, even though a rather succinct review appears in the introductory chapter 0. The reader should also be very familiar with elementary analysis. Some familiarity with Group Theory is required for chapters 5, 6 and 8.

For a detailed treatment see [1].

The problems which appear at the end of each chapter not only provide ample opportunity for applying the concepts and techniques just learned but also are used to introduce additional concepts and techniques which complement the text and point to further study elsewhere.

I am indebted to many students who, over many years, have made very useful suggestions on the presentation that follows. I am also indebted to Ida Orahood, Lori Carranza and Josh Walters who typed the first drafts of this book, and I am especially indebted to John Gehrmann who did the final revision of the text. I am also very indebted to Dr. Sunil Nair who encouraged me and helped me publish this book.

Carlos R. Borges
December 1999