

# Contents

<b>To the student</b>	<b>v</b>
<b>Preface</b>	<b>vi</b>
<b>1 Linear systems and vector spaces</b>	<b>1</b>
1.1 Linear systems of equations . . . . .	1
1.2 Gaussian elimination . . . . .	11
1.3 Vectors and the geometry of linear systems . . . . .	27
1.4 Fields . . . . .	41
1.5 Vector spaces . . . . .	53
<b>2 Linear maps and matrices</b>	<b>66</b>
2.1 Linear maps . . . . .	66
2.2 More on linear maps . . . . .	82
2.3 Matrix multiplication . . . . .	95
2.4 Range, kernel, and eigenspaces . . . . .	115
2.5 Error-correcting linear codes . . . . .	131
<b>3 Linear independence, bases, and coordinates</b>	<b>142</b>
3.1 Linear (in)dependence . . . . .	142
3.2 Bases . . . . .	153
3.3 Dimension . . . . .	166
3.4 Rank and nullity . . . . .	177
3.5 Coordinates . . . . .	190
3.6 Change of basis . . . . .	204
3.7 Triangularization . . . . .	218
<b>4 Inner products</b>	<b>229</b>
4.1 Inner products . . . . .	229
4.2 Orthonormal bases . . . . .	244
4.3 Orthogonal projections and optimization . . . . .	257
4.4 Normed spaces . . . . .	271
4.5 Isometries . . . . .	281

<b>5</b>	<b>Singular value decomposition and the spectral theorem</b>	<b>292</b>
5.1	Singular value decomposition of linear maps . . . . .	292
5.2	Singular value decomposition of matrices . . . . .	301
5.3	Adjoint maps . . . . .	314
5.4	The Spectral Theorems . . . . .	323
<b>6</b>	<b>Determinants</b>	<b>334</b>
6.1	Determinants . . . . .	334
6.2	Computing determinants . . . . .	349
6.3	Characteristic polynomials . . . . .	361
6.4	Applications of determinants . . . . .	370
	<b>Appendix</b>	<b>383</b>
A.1	Sets and functions . . . . .	383
A.2	Complex numbers . . . . .	388
A.3	Proofs . . . . .	391
	<b>Addendum</b>	<b>396</b>
	<b>Index</b>	<b>397</b>