

Table of Contents

Preface	v
1 First Order Equations	1
1.1 Four Examples : Linear versus Nonlinear	1
1.2 The Calculus You Need	4
1.3 The Exponentials e^t and e^{at}	9
1.4 Four Particular Solutions	17
1.5 Real and Complex Sinusoids	30
1.6 Models of Growth and Decay	40
1.7 The Logistic Equation	53
1.8 Separable Equations and Exact Equations	65
2 Second Order Equations	73
2.1 Second Derivatives in Science and Engineering	73
2.2 Key Facts About Complex Numbers	82
2.3 Constant Coefficients A, B, C	90
2.4 Forced Oscillations and Exponential Response	103
2.5 Electrical Networks and Mechanical Systems	118
2.6 Solutions to Second Order Equations	130
2.7 Laplace Transforms $Y(s)$ and $F(s)$	139
3 Graphical and Numerical Methods	153
3.1 Nonlinear Equations $y' = f(t, y)$	154
3.2 Sources, Sinks, Saddles, and Spirals	161
3.3 Linearization and Stability in 2D and 3D	170
3.4 The Basic Euler Methods	184
3.5 Higher Accuracy with Runge-Kutta	191
4 Linear Equations and Inverse Matrices	197
4.1 Two Pictures of Linear Equations	197
4.2 Solving Linear Equations by Elimination	210
4.3 Matrix Multiplication	219
4.4 Inverse Matrices	228
4.5 Symmetric Matrices and Orthogonal Matrices	238

5	Vector Spaces and Subspaces	251
5.1	The Column Space of a Matrix	251
5.2	The Nullspace of A : Solving $Av = 0$	261
5.3	The Complete Solution to $Av = b$	273
5.4	Independence, Basis and Dimension	285
5.5	The Four Fundamental Subspaces	300
5.6	Graphs and Networks	313
6	Eigenvalues and Eigenvectors	325
6.1	Introduction to Eigenvalues	325
6.2	Diagonalizing a Matrix	337
6.3	Linear Systems $y' = Ay$	349
6.4	The Exponential of a Matrix	362
6.5	Second Order Systems and Symmetric Matrices	372
7	Applied Mathematics and $A^T A$	385
7.1	Least Squares and Projections	386
7.2	Positive Definite Matrices and the SVD	396
7.3	Boundary Conditions Replace Initial Conditions	406
7.4	Laplace's Equation and $A^T A$	416
7.5	Networks and the Graph Laplacian	423
8	Fourier and Laplace Transforms	432
8.1	Fourier Series	434
8.2	The Fast Fourier Transform	446
8.3	The Heat Equation	455
8.4	The Wave Equation	463
8.5	The Laplace Transform	470
8.6	Convolution (Fourier and Laplace)	479
	Matrix Factorizations	490
	Properties of Determinants	492
	Index	493
	Linear Algebra in a Nutshell	502