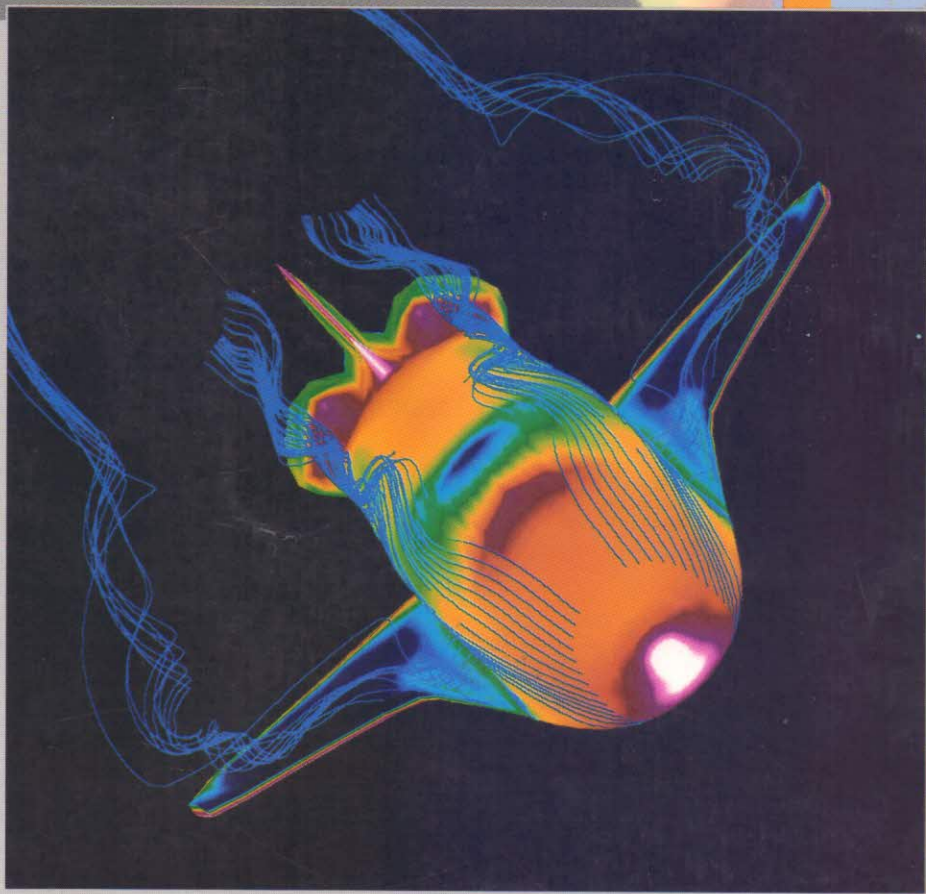


ENGINEERING PROBLEM SOLVING WITH MATLAB[®]



DISK INCLUDED



D. M. ETTER



MATLAB[®]
CURRICULUM
SERIES

Contents

Foreword xvii

Preface xix

PART I INTRODUCTION 1

1 An Introduction to Problem Solving 3

1.1 Engineering Challenges 4

Challenges Met 4

Moon Landing 4

Application Satellites 4

Microprocessors 5

Computer-Aided Design and Manufacturing 5

CAT Scans 5

Advanced Composite Materials 6

Jumbo Jets 6

Lasers 6

Fiber-Optic Communications 7

Genetically Engineered Products 7

Grand Challenges Remaining 7

Prediction of Weather, Climate, and Global Change 8

Speech Recognition and Understanding 8

Machine Vision 8

Vehicle Performance 9

Superconductivity 9

Enhanced Oil and Gas Recovery 9

Nuclear Fusion 10

1.2 An Engineering Problem Solving Methodology 10

1.3 Analyzing Climatology Data 13

Summary 17

Problems 18

Suggested Readings 18

2 An Introduction to MATLAB 21

- 2.1 Computing Systems 22
 - Computer Hardware 22
 - Computer Software 23
 - Operating Systems 23
 - Software Tools 23
 - Computer Languages 24
- 2.2 General MATLAB Information 25
 - Student Edition 25
 - Workspace Information 25
 - M-Files 27
- 2.3 Matrices, Vectors, and Scalars 27
 - Initializing Matrices 29
 - Explicit Lists 29
 - Data Files 31
 - Colon Operator 32
 - User Input 34
 - Printing Matrices 35
 - Display Format 35
 - Printing Text or Matrices 36
 - Formatted Output 36
 - X-Y Plots 37
 - Problem Solving Applied: Wind Tunnel Data Analysis* 40
 - Summary 43
 - MATLAB Summary 43
 - Problems 45

PART II FUNDAMENTAL ENGINEERING COMPUTATIONS 47

3 Scalar and Array Computations 49

- 3.1 Special Values and Special Matrices 50
 - Special Values 50
 - Special Matrices 50
 - Magic Squares 50
 - Matrix of Zeros 51
 - Matrix of Ones 51
 - Identity Matrix 52
 - Pascal's Triangle 53

- 3.2 Scalar Operations 53
 - Precedence of Arithmetic Operations 54
 - Computational Limitations 56
- 3.3 Array Operations 57
 - Problem Solving Applied: Echoes in Communication Signals* 61
- 3.4 Common Functions 67
 - Elementary Math Functions 69
 - Trigonometric Functions 70
 - Hyperbolic Functions 72
 - M-File Functions 73
 - Problem Solving Applied: Sonar Signals* 74
- 3.5 Complex Numbers 80
 - Arithmetic Operations with Complex Numbers 81
 - Polar and Rectangular Coordinates 83
 - Euler's Formula 85
 - Summary 86
 - MATLAB Summary 87
 - Problems 88

4 Control Flow 93

- 4.1 If Statements 94
 - Relational Operators 94
 - Simple If Statement 96
 - Relational and Logical Functions 98
 - Else Clause 99
 - Elseif Clause 100
- 4.2 For Loops 102
 - Problem Solving Applied: Optical Fibers* 104
- 4.3 While Loops 108
 - Problem Solving Applied: Temperature Equilibrium* 109
 - Summary 113
 - MATLAB Summary 113
 - Problems 114

5 Statistical Measurements 121

- 5.1 Data Analysis Functions 122
 - Simple Analysis 122
 - Maximum and Minimum 122
 - Mean and Median 122
 - Sums and Products 123

	Variance and Standard Deviation	125
	Histograms	127
	<i>Problem Solving Applied: Speech Signal Analysis</i>	129
5.2	Random Numbers	132
	Random Number Function	132
	Uniform Random Numbers	133
	Gaussian Random Numbers	137
	Density Functions	140
	<i>Problem Solving Applied: Flight Simulator</i>	142
5.3	Signal-to-Noise Ratios	146
	Signal Power	147
	Computation of SNR	148
	Adding Noise to an Existing Signal	149
	Summary	150
	MATLAB Summary	150
	Problems	150
6	Matrix Computations	157
6.1	Matrix Operations	158
	Transpose of a Matrix	158
	Dot Product	158
	Matrix Multiplication	159
	Matrix Powers	161
	Matrix Inverse	162
	Determinants	163
	<i>Problem Solving Applied: Molecular Weights of Proteins</i>	164
6.2	Matrix Manipulations	168
	Rotation	168
	Flip	168
	Reshape	169
	Extraction	169
	<i>Problem Solving Applied: Image Alignment</i>	172
	Summary	175
	MATLAB Summary	176
	Problems	176
7	Plotting Capabilities	181
7.1	X-Y Plots	182
	Rectangular Coordinates	182
	Labels	182
	Plot Commands	183

7.2	Polar Plots	185
	Polar Coordinates	186
	Polar Command	186
	Rectangular/Polar Transformations	186
7.3	Bar Graps and Stair Graphs	188
7.4	Plotting Options	189
	Multiple Plots	189
	Line and Mark Style	190
	Scaling	191
	Subplot	191
	Screen Control	191
	Graph Screen Input	192
	Graphics Hardcopy	192
	<i>Problem Solving Applied: Sounding Rocket Trajectory</i>	192
7.5	3-D Plots	199
	Mesh Surfaces	199
	Viewing Angles	200
	Scale Factors	201
	Contour Plots	203
	<i>Problem Solving Applied: Terrain Navigation</i>	205
	Summary	208
	MATLAB Summary	208
	Problems	209

PART III NUMERICAL TECHNIQUES 213

8 Solutions to Systems of Linear Equations 215

8.1	Graphical Interpretation	215
8.2	Solutions Using Matrix Operations	219
	Matrix Division	220
	Matrix Inverse	221
	<i>Problem Solving Applied: Electrical Circuit Analysis</i>	223
	Summary	226
	MATLAB Summary	227
	Problems	227

9 Interpolation and Curve Fitting 231

9.1	Interpolation	232
	Linear Interpolation	232
	Table1 Function	233

Table2 Function 235
Cubic Spline Interpolation 236
Problem Solving Applied: Robot Arm Manipulators 238

9.2 Least Squares Curve Fitting 242
Linear Regression 243
Polynomial Regression 246
Polyfit and Polyval Functions 247
Summary 248
MATLAB Summary 249
Problems 249

10 Polynomial Analysis 253

10.1 Computations with Polynomials 254
Evaluation 254
Arithmetic Operations 255
Problem Solving Applied: Weather Balloons 258
10.2 Roots of Polynomials 261
Summary 265
MATLAB Summary 266
Problems 266

11 Numerical Integration and Differentiation 269

11.1 Numerical Integration 270
Trapezoidal Rule and Simpson's Rules 270
MATLAB Quadrature Functions 272
Problem Solving Applied: Pipeline Flow Analysis 274
11.2 Numerical Differentiation 278
Difference Expressions 279
DIFF Function 280
Summary 283
MATLAB Summary 284
Problems 284

12 Ordinary Differential Equations 287

12.1 First-Order Ordinary Differential Equations 288
12.2 Runge-Kutta Methods 289
First-Order Approximation (Euler's Method) 290
MATLAB ODE Function 291
Equation 1 292
Equation 2 292
Equation 3 293

	Equation 4	293
	Equation 5	294
	<i>Problem Solving Applied: Acceleration of UDF-Powered Aircraft</i>	296
12.3	Higher-Order Differential Equations	299
	Summary	300
	MATLAB Summary	300
	Problems	301
13	Matrix Decomposition and Factorization	307
13.1	Eigenvalues and Eigenvectors	308
	<i>Problem Solving Applied: Adaptive Noise Canceling</i>	311
13.2	Decompositions and Factorizations	313
	Triangular Factorization	313
	QR Factorization	315
	Singular Value Decomposition	315
	Summary	316
	MATLAB Summary	316
	Problems	316
14	Signal Processing	321
14.1	Frequency Domain Analysis	322
14.2	Filter Analysis	329
	Analog Transfer Functions	331
	Digital Transfer Functions	333
	Partial Fraction Expansions	337
14.3	Digital Filter Implementation	340
14.4	Digital Filter Design	343
	IIR Filter Design Using Analog Prototypes	343
	Direct IIR Filter Design	345
	Direct FIR Filter Design	347
	<i>Problem Solving Applied: Channel Separation Filters</i>	349
	Summary	352
	MATLAB Summary	352
	Problems	353
15	Control Systems	357
15.1	System Modeling	358
	Transfer Functions	359
	State-Space Models	361
	Discrete-Time Systems	361

15.2	Model Conversion	362
	c2d Function	363
	residue Function	363
	ss2tf Function	364
	ss2zp Function	365
	tf2ss Function	366
	tf2zp Function	367
	zp2ss Function	368
	zp2tf Function	369
15.3	Design and Analysis Functions	371
	Bode Plots	371
	Nyquist Plots	374
	Root Locus Plots	378
	Step Response	382
	Optimal System Design	385
	<i>Problem Solving Applied: Laser Beam Steering Mirror Control</i>	389
	Summary	391
	MATLAB Summary	392
	Problems	392

Appendix A A Quick Reference to MATLAB Functions 396

Appendix B Reading and Writing MAT-Files 404

MS-DOS Subroutines	404
C Programs	404
Pascal Programs	404
Fortran Programs	404
Macintosh Subroutines	405
C Language Programs	406
Fortran Programs	406

Appendix C MATLAB on MS-DOS PCs 407

Invoking MATLAB	407
Command Line Editor	407
Editors and External Programs	407
Environment Parameters	409
PATH	409
MATLABPATH	410
Increasing Environment Space	411
Printing with Screen Dumps	411

Appendix D MATLAB on the Macintosh 413

MATLAB Window Types	413
Command Window	413
Graph Window	414
Edit Window	414
Help Window	414
Using the Clipboard	415
Invoking MATLAB	416
Printing	417

Appendix E References 418

Solutions to Selected Problems	419
Index	425