Contents

Part I		Funda	mental Engineering Computing	1
	1	Engineering Problem Solving Grand Challenge: Weather Prediction		2
		1.1 Er	ngineering in the 21st Century	4
			cent Engineering Achievements	4
			rand Challenges for the Future	8
		Cl	nanging Engineering Environment	10
		12 C	omputing Systems	11
		C	omputer Hardware	11
			omputer Software	14
			Operating Systems	14
			Software Tools	15
			Computer Languages	16
			Executing a Computer Program	18
			Executing a MATLAB Program	19
			Software Life Cycle	19
		т	ne Internet, Email, and the World Wide Web	20
		1.3 A	n Engineering Problem-Solving Methodology	21
		1.5 A	ata Collection for Weather Prediction	25
			hapter Summary, Key Terms,	
			roblems, Suggested Readings	28
	2		AB Environment	32
	_	IVIATLA	R FIIAII ÒIIIIEILE	
		Grand	Challenge: Vehicle Performance	
		2.1 C	haracteristics of the MATLAB Environment	34
			tudent Edition Version 4	34
			IATLAB Windows	34
			calars, Vectors, and Matrices	35
			nitialization	37
es#		_	Explicit Lists	37
•			Colon Operator	39
			Special Values and Special Matrices	4:
			User Input	43

		Output Options	43
		Display Format	4 3
		Printing Text and Values	44
		Formatted Output	4 5
		Simple xy Plots	46
		Data Files	47
	2.3	V 1.	49
		Scalar Operations	49
		Array Operations	50
		Precedence of Arithmetic Operations	52
		Computational Limitations	54
	2.4	0 - T	<i>55</i>
		Linear and Logarithmic Plots	<i>55</i>
		Multiple Plots	<i>57</i>
		Line and Mark Style	<i>58</i> .
		Axes Scaling	58
		Subplots	< <i>59</i>
	2.5	Problem Solving Applied:	
		Advanced Turborpop Engine	59
		Chapter Summary, Key Terms, MATLAB Summary,	
		Style Notes, Debugging Notes, Problems	63
_			
_			
3	MA	TLAB Functions	68
3		TLAB Functions nd Challenge: Speech Recognition	68
3			68
3	Gra	nd Challenge: Speech Recognition Mathematical Functions Common Math Functions	
3	Gra	nd Challenge: Speech Recognition Mathematical Functions Common Math Functions	70
3	Gra	nd Challenge: Speech Recognition Mathematical Functions	70 71
3	Gra	nd Challenge: Speech Recognition Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates	70 71 72
3	Gra	nd Challenge: Speech Recognition Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions	70 71 72 75
3	Gra	nd Challenge: Speech Recognition Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates	70 71 72 75 75
3	Gra	nd Challenge: Speech Recognition Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates Euler's Formula	70 71 72 75 75 77
3	Gra	Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates Euler's Formula Polar Plots Polynomial Functions Polynomial Evaluation	70 71 72 75 75 77 78
3	Gra	Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates Euler's Formula Polar Plots Polynomial Functions	70 71 72 75 75 77 78 78
3	Gra	Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates Euler's Formula Polar Plots Polynomial Functions Polynomial Evaluation	70 71 72 75 75 77 78 78 80
3	Gra	Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates Euler's Formula Polar Plots Polynomial Functions Polynomial Evaluation Polynomial Operations Roots of Polynomials Functions of Two Variables	70 71 72 75 75 77 78 78 80 80
3	Gra	Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates Euler's Formula Polar Plots Polynomial Functions Polynomial Evaluation Polynomial Operations Roots of Polynomials	70 71 72 75 75 77 78 78 80 80 80
3	Gra	Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates Euler's Formula Polar Plots Polynomial Functions Polynomial Evaluation Polynomial Operations Roots of Polynomials Functions of Two Variables Function Evaluation 3-D Plots	70 71 72 75 75 77 78 78 80 80 80 83 86
3	Gra	Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates Euler's Formula Polar Plots Polynomial Functions Polynomial Evaluation Polynomial Operations Roots of Polynomials Functions of Two Variables Function Evaluation	70 71 72 75 75 77 78 78 80 80 80 83 86 86
3	Gra	Mathematical Functions Common Math Functions Trigonometric and Hyperbolic Functions Complex Number Functions Rectangular and Polar Coordinates Euler's Formula Polar Plots Polynomial Functions Polynomial Evaluation Polynomial Operations Roots of Polynomials Functions of Two Variables Function Evaluation 3-D Plots	70 71 72 75 75 77 78 78 80 80 80 83 86 86 86

		CONTENT	s xvii
		Maximum and Minimum	92
		Sums and Products	92
		Mean and Median	92
		Sorting Values	93
		Variance and Standard Deviation	94
		Histograms	95
	3.3		96
		Simple if Statement	96
		Relational and Logical Operators	97
		Nested if Statements	100
		else and elseif Clauses	100
	2.4	Logical Functions	101
	3.4	0 11	103
	٥.	Speech Signal Analysis	103
		User-Written Functions	108
	3.6	Random Number Generating Functions Uniform Random Numbers	108
		Gaussian Random Numbers	110
	3.7		110
	3.7	Rotation	112
		Flipping	112
		Reshaping	112
		Esteration	113
	3.8	E wage?	116
	0.0	for Loop	116
		while Loop	117
		Chapter Summary, Key Terms, MATLAB Summary,	
		Style Notes, Debugging Notes, Problems	118
4		Al. It is an all Markets	124
+	Lin	ear Algebra and Matrices	124
	Gra	nd Challenge: Mapping the Human Genome	
	4.1	Matrix Operations	126
		Transpose	126
		Dot Product	126
		Matrix Multiplication	127
		Matrix Powers	129
		Matrix Polynomials	129
	4.2	Problem Solving Applied:	
		Protein Molecular Weights	130
	4.3	Matrix Functions	134
		Matrix Inverse and Rank	134

TAP		Determinants Eigenvectors and Eigenvalues Decompositions Triangular Factorizations QR Factorization Singular Value Decomposition Chapter Summary, Key Terms, Matlab Summary, Style Notes, Debugging Notes, Problems	135 136 140 140 141 142
Part II		Numerical Techniques	147
	5	Solutions to Systems of Linear Equations	148
		Grand Challenge: Vehicle Performance	
		 5.1 Graphical Interpretation 5.2 Solutions Using Matrix Operations Matrix Division Matrix Inverse 5.3 Problem Solving Applied: Electrical Circuit Analysis Chapter Summary, Key Terms, MATLAB Summary, Style Notes, Debugging Notes, Problems 	150 151 155 156 157
	6	Interpolation and Curve Fitting	164
		Grand Challenge: Vehicle Performance	
		 6.1 Interpolation Linear Interpolation Cubic-Spline Interpolation 6.2 Problem Solving Applied: Robot Arm Manipulators 6.3 Least-Squares Curve Fitting Linear Regression Polynomial Regression polyfit Function Chapter Summary, Key Terms, MATLAB Summary, 	166 168 170 174 175 177
	7	Style Notes, Debugging Notes, Problems Numerical Integration and Differentiation	180 18 4
	•	Grand Challenge: Enhanced Oil and Gas Recovery	.5.
		7.1 Numerical Integration Trapezoidal Rule and Simpson's Rule Ouadrature Functions	186 186 187

		•	CONTENTS	xix
		 7.2 Problem Solving Applied: Pipeline Flow Analysis 7.3 Numerical Differentiation Difference Expressions aiff Function Chapter Summary, Key Terms, Matlab Summary, Style Notes, Debugging Notes, Problems 	mary,	189 193 194 195
	0			202
	8	Ordinary Differential Equations		202
		Grand Challenge: Vehicle Performance		
		8.1 First-Order Ordinary Differential Equations		204
		8.2 Runge-Kutta Methods		205 205
		First-Order Approximation (Euler's Method) ode Fundations		207
		8.3 Problem Solving Applied:		
		Acceleration of UDF-Powered Aircraft		212
		8.4 Higher-Order Differential Equations	.m. 0.867	215
		Chapter Summary, Key Terms, MATLAB Sum Style Notes, Debugging Notes, Problems	illary,	217
Part III		Special Topics		223
	9	Symbolic Mathematics		224
19. T		Grand Challenge: Weather Prediction		226
rvi e		9.1 Symbolic Algebra Symbolic Expressions		226
* \$4.		Simplification of Mathematical Expressions		227
er J.		Operations on Symbolic Expressions		228
		9.2 Equation Solving		229 229
ing the Bernard American State of the State		Solutions to Equations Solutions to Differential Equations		223
		9.3 Differentiation and Integration		232
		Differentiation		232
		Integration		233
		9.4 Problem Solving Applied:		234
		Weather Balloons Chapter Summary, Key Terms, Matlab Sur	nmary,	201
		Style Notes, Debugging Notes, Problems	, , , , , , , , , , , , , , , , , , ,	237
		- 7		

10	Sign	nal Processing	240		
	Grand Challenge: Computerized Speech Understanding				
	10.1	Frequency Domain Analysis	242		
	10.2	Filter Analysis	248		
		Analog Transfer Functions	250		
		Digital Transfer Functions	252		
		Partial Fraction Expansions	256		
	10.3	Digital Filter Implementation	260		
	10.4	Digital Filter Design	263		
		IIR Filter Design Using Analog Prototypes	263		
		Direct IIR Filter Design	267		
		Direct FIR Filter Design	268		
	10.5	Problem Solving Applied:			
		Channel Separation Filters	270		
		Chapter Summary, Key Terms, Matlab Summary,			
		Style Notes, Debugging Notes, Problems	272		
11	Control Systems				
	Grand Challenge: Vehicle Performance				
	11.1	System Modeling	280		
		Transfer Functions	281		
		State-Space Models	282		
		Discrete-Time Systems	283		
	11.2	Model Conversion	284		
	11.3	,	292		
		Bode Plots	292		
		Nyquist Plots	297		
		Root-Locus Plots	299		
		Step Response	302		
	11.4	Problem Solving Applied:			
		Laser Beam Steering Mirror Control	305		
		Chapter Summary, Key Terms, Matlab Summary,			
		Style Notes, Debugging Notes, Problems	307		
Αp	pend	dix A Matlab Function Summary	311		
Co	mple	ete Solutions to Practice! Problems	315		
Ind	dex		326		