

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Introduction . . . . .	1
1.2	Notation . . . . .	3
1.3	Applications . . . . .	4
1.4	Previous Research . . . . .	4
1.5	Figures . . . . .	5
1.5.1	Maple . . . . .	5
1.5.2	LaTeX . . . . .	5
1.5.3	Simulink . . . . .	6
1.5.4	Color . . . . .	6
1.6	References . . . . .	6
<b>2</b>	<b>Fuzzy Sets</b>	<b>9</b>
2.1	Introduction . . . . .	9
2.2	Fuzzy Sets . . . . .	9
2.2.1	Fuzzy Numbers . . . . .	10
2.2.2	Alpha-Cuts . . . . .	10
2.2.3	Inequalities . . . . .	12
2.2.4	Discrete Fuzzy Sets . . . . .	12
2.3	Fuzzy Arithmetic . . . . .	12
2.3.1	Extension Principle . . . . .	12
2.3.2	Interval Arithmetic . . . . .	13
2.3.3	Fuzzy Arithmetic . . . . .	14
2.4	Fuzzy Functions . . . . .	15
2.4.1	Extension Principle . . . . .	15
2.4.2	Alpha-Cuts and Interval Arithmetic . . . . .	16
2.4.3	Differences . . . . .	17
2.5	Fuzzy Differential Equations . . . . .	18
2.6	References . . . . .	19

<b>3</b>	<b>Fuzzy Estimation</b>	<b>21</b>
3.1	Introduction . . . . .	21
3.2	Expert Opinion . . . . .	21
3.3	Fuzzy Estimators from Confidence Intervals . . . . .	22
3.3.1	Fuzzy Estimator of $\mu$ . . . . .	23
3.4	Fuzzy Arrival/Service Rates . . . . .	24
3.4.1	Fuzzy Arrival Rate . . . . .	25
3.4.2	Fuzzy Service Rate . . . . .	26
3.5	Fuzzy Estimator of $p$ in the Binomial . . . . .	28
3.6	Fuzzy Estimator of the Mean of the Normal Distribution . . .	30
3.7	Summary . . . . .	31
3.8	References . . . . .	31
<b>4</b>	<b>Fuzzy Systems</b>	<b>33</b>
4.1	Introduction . . . . .	33
4.2	Fuzzy System . . . . .	35
4.3	Computing the Uncertainty Band . . . . .	35
4.4	Uncertainty Band as a Confidence Band . . . . .	36
4.5	References . . . . .	36
<b>5</b>	<b>Continuous Simulation Software</b>	<b>39</b>
5.1	Software Selection . . . . .	39
5.2	References . . . . .	41
<b>6</b>	<b>Simulation Optimization</b>	<b>43</b>
6.1	Introduction . . . . .	43
6.2	Theory . . . . .	44
6.3	Summary . . . . .	47
6.4	References . . . . .	47
<b>7</b>	<b>Predator/Prey Models</b>	<b>49</b>
7.1	Introduction . . . . .	49
7.2	Parameters . . . . .	50
7.3	Simulation . . . . .	50
7.4	References . . . . .	53
<b>8</b>	<b>An Arm's Race Model</b>	<b>55</b>
8.1	Introduction . . . . .	55
8.2	Parameters . . . . .	56
8.3	First Simulation . . . . .	56
8.4	Second Simulation . . . . .	59
8.5	References . . . . .	61

<b>9 Bungee Jumping</b>	<b>63</b>
9.1 Introduction . . . . .	63
9.2 Parameters . . . . .	63
9.3 First Simulation . . . . .	64
9.4 Second Simulation . . . . .	66
9.5 References . . . . .	67
<b>10 Spread of Infectious Disease Model</b>	<b>69</b>
10.1 Introduction . . . . .	69
10.2 Parameters . . . . .	70
10.3 Simulation . . . . .	71
10.4 References . . . . .	74
<b>11 Planetary Motion</b>	<b>75</b>
11.1 Introduction . . . . .	75
11.2 Parameters . . . . .	75
11.3 Simulation . . . . .	77
11.4 References . . . . .	79
<b>12 Human Cannon Ball</b>	<b>81</b>
12.1 Introduction . . . . .	81
12.2 Parameters . . . . .	82
12.3 First Simulation . . . . .	83
12.4 Second Simulation . . . . .	84
12.5 References . . . . .	86
<b>13 Electrical Circuits</b>	<b>87</b>
13.1 Introduction . . . . .	87
13.2 Parameters . . . . .	88
13.3 Simulation . . . . .	90
13.4 References . . . . .	93
<b>14 Hawks, Doves and Law-Abiders</b>	<b>95</b>
14.1 Introduction . . . . .	95
14.2 Parameters . . . . .	96
14.3 First Simulation . . . . .	97
14.4 Second Simulation . . . . .	99
14.5 Third Simulation . . . . .	102
14.6 Summary . . . . .	104
14.7 References . . . . .	104
<b>15 Suspension System</b>	<b>105</b>
15.1 Introduction . . . . .	105
15.2 Parameters . . . . .	106
15.3 Simulation . . . . .	107
15.4 References . . . . .	110

<b>16 Chemical Reactions</b>	<b>111</b>
16.1 Introduction . . . . .	111
16.2 Parameters . . . . .	111
16.3 Simulation . . . . .	113
16.4 References . . . . .	116
<b>17 The AIDS Epidemic</b>	<b>117</b>
17.1 Introduction . . . . .	117
17.2 Parameters . . . . .	118
17.3 Simulation . . . . .	120
17.4 References . . . . .	124
<b>18 The Machine/Service Queuing Model</b>	<b>125</b>
18.1 Introduction . . . . .	125
18.2 Parameters . . . . .	126
18.3 First Simulation . . . . .	127
18.4 Second Simulation . . . . .	128
18.5 References . . . . .	131
<b>19 A Self-Service Queuing Model</b>	<b>133</b>
19.1 Introduction . . . . .	133
19.2 Parameters . . . . .	134
19.3 Simulation . . . . .	135
19.4 References . . . . .	137
<b>20 Symbiosis</b>	<b>139</b>
20.1 Introduction . . . . .	139
20.2 Parameters . . . . .	139
20.3 Simulation . . . . .	140
20.4 References . . . . .	143
<b>21 Supply and Demand</b>	<b>145</b>
21.1 Introduction . . . . .	145
21.2 Parameters . . . . .	145
21.3 Simulation . . . . .	146
21.4 References . . . . .	149
<b>22 Drug Concentrations</b>	<b>151</b>
22.1 Introduction . . . . .	151
22.2 Parameters . . . . .	152
22.3 Simulation . . . . .	153
22.4 References . . . . .	156

<b>23 Three Species Competition</b>	<b>157</b>
23.1 Introduction . . . . .	157
23.2 Parameters . . . . .	157
23.3 Simulation . . . . .	158
23.4 References . . . . .	161
<b>24 Flying a Glider</b>	<b>163</b>
24.1 Introduction . . . . .	163
24.2 Parameters . . . . .	163
24.3 Simulation . . . . .	165
24.4 References . . . . .	166
<b>25 The National Economy</b>	<b>167</b>
25.1 Introduction . . . . .	167
25.2 Parameters . . . . .	167
25.3 First Simulation: Case #1 . . . . .	168
25.4 Second Simulation: Case #2 . . . . .	169
25.5 Third Simulation: Case #3 . . . . .	172
25.6 References . . . . .	174
<b>26 Sex Structured Population Models</b>	<b>175</b>
26.1 Introduction . . . . .	175
26.2 Parameters . . . . .	176
26.3 Simulation . . . . .	176
26.4 References . . . . .	179
<b>27 Summary and Future Research</b>	<b>181</b>
27.1 Summary . . . . .	181
27.2 Future Research . . . . .	183
27.3 Conclusions . . . . .	183
27.4 References . . . . .	184
<b>28 Matlab/Simulink Commands for Graphs</b>	<b>185</b>
28.1 Introduction . . . . .	185
28.2 Simulink Diagrams (.mdl files) . . . . .	186
28.3 Parameters . . . . .	186
28.4 Matlab Commands (.m files) . . . . .	188
28.5 Availability of Files . . . . .	190
28.6 References . . . . .	190
<b>Index</b>	<b>191</b>
<b>List of Figures</b>	<b>197</b>
<b>List of Tables</b>	<b>201</b>