
Contents

Foreword	VII
Series Preface	IX
Preface	XI
1 Static Design Issues	1
1.1 The Lone Pump	1
1.2 Heart “Disease”?	3
1.3 Origin of Coronary Blood Supply	5
1.4 Coronary Arteries	7
1.5 Left/Right Dominance	12
1.6 Branching Structure	14
1.7 Underlying Design?	21
1.8 Coronary Flow Reserve	27
1.9 Design Conflict?	31
1.10 Summary	32
2 Modelling Preliminaries	35
2.1 Why Modelling?	35
2.2 The “Lumped Model” Concept	37
2.3 Flow in a Tube	38
2.4 Fluid Viscosity: Resistance to Flow	41
2.5 Fluid Inertia: Inductance	45
2.6 Elasticity of the Tube Wall: Capacitance	56
2.7 Elasticity of the Tube Wall: Wave Propagation	62
2.8 Mechanical Analogy	66
2.9 Electrical Analogy	71
2.10 Summary	75

3	Basic Lumped Elements	79
3.1	Introduction	79
3.2	RLC System in Series	81
3.3	Free Dynamics of the RLC System in Series.....	84
3.4	R1,R2 in Parallel	88
3.5	R,L in Parallel	92
3.6	R,C in Parallel	97
3.7	RLC System in Parallel Under Constant Pressure	101
3.8	RLC System in Parallel Under Constant Flow.....	103
3.9	Summary.....	112
4	Forced Dynamics of the RLC System	115
4.1	Introduction	115
4.2	The Particular Solution	116
4.3	Using the Complex Exponential Function.....	117
4.4	Overdamped Forced Dynamics	119
4.5	Underdamped Forced Dynamics	122
4.6	Critically Damped Forced Dynamics	124
4.7	Transient and Steady States	126
4.8	The Concept of Reactance	131
4.9	The Concepts of Impedance, Complex Impedance	137
4.10	Summary.....	142
5	The Analysis of Composite Waveforms	145
5.1	Introduction	145
5.2	Basic Theory	148
5.3	Example: Single-Step Waveform	151
5.4	Example: Piecewise Waveform	157
5.5	Numerical Formulation	164
5.6	Example: Cardiac Waveform	169
5.7	Summary.....	174
6	Composite Pressure-Flow Relations	177
6.1	Introduction	177
6.2	Composite Pressure-Flow Relations Under Pure Resistance ...	179
6.3	Example: Cardiac Pressure Wave	181
6.4	Composite Pressure-Flow Relations Under General Impedance	186
6.5	Composite Pressure-Flow Relations Under Inertial Effects ...	190
6.6	Composite Pressure-Flow Relations Under Capacitance Effects	198
6.7	Composite Pressure-Flow Relations Under RLC in Series	207
6.8	Composite Pressure-Flow Relations Under RLC in Parallel ...	213
6.9	Summary.....	219

7	Lumped Models	221
7.1	Introduction	221
7.2	LM0: $\{R,C\}$	222
7.3	LM1: $\{R1,\{R2+C\}\}$	229
7.4	LM2: $\{\{R1+L\},\{R2+C\}\}$	235
7.5	LM3: $\{\{R1+(pb)\},\{R2+C\}\}$	241
7.6	Inflow-Outflow	249
7.7	Summary	252
8	Elements of Unlumped-Model Analysis	255
8.1	Introduction	255
8.2	The Streamwise Space Dimension	256
8.3	Steady Flow along Tube Segments	258
8.4	Steady Flow Through a Bifurcation	265
8.5	Pulsatile Flow in a Rigid Tube	272
8.6	Pulsatile Flow in an Elastic Tube	279
8.7	Wave Reflections	287
8.8	Summary	297
9	Basic Unlumped Models	299
9.1	Introduction	299
9.2	Steady Flow in Branching Tubes	300
9.3	Pulsatile Flow in Rigid Branching Tubes	307
9.4	Elastic Branching Tubes	313
9.5	Effective Impedance, Admittance	317
9.6	Pulsatile Flow in Elastic Branching Tubes	329
9.7	Cardiac Pressure Wave in Elastic Branching Tubes	343
9.8	Summary	358
10	Dynamic Pathologies	361
10.1	Introduction	361
10.2	Magic Norms?	362
10.3	Coronary Heart Disease, Physical Exercise, and the Conundrum of Coronary Flow Reserve	370
10.4	Wave Propagation Through a Coronary Bypass	378
10.5	Wave Propagation Through a Coronary Stent	381
10.6	Sudden Cardiac Death	384
10.7	Broken Heart Syndrome	387
10.8	Summary	388
	References	391
	Index	403