

# CONTENTS

<b>PREFACE</b>	<b>xiii</b>
<b>ACKNOWLEDGMENTS</b>	<b>xvii</b>
<b>ABOUT THE AUTHOR</b>	<b>xix</b>
<b>CHAPTER 1 THE CHEMICAL ENGINEERING PROFESSION</b>	<b>1</b>
1.1 Engineering and Engineers	2
1.2 Engineering Disciplines	8
1.3 Defining Chemical Engineering	12
1.4 Roles and Responsibilities of a Chemical Engineer	14
1.5 Employment of Chemical Engineers	19
1.6 Summary	22
<b>CHAPTER 2 CHEMICAL AND ALLIED INDUSTRIES</b>	<b>27</b>
2.1 Classification of Industries	27
2.2 The Chemical Industry	29
2.2.1 Basic Inorganic Chemicals	29
2.2.2 Industrial Gases	29
2.2.3 Basic Organic Chemicals and Petrochemicals	30
2.2.4 Fertilizer Products	31
2.2.5 Polymer Products	32

2.2.6	Pharmaceutical Products	34
2.2.7	Other Chemical Products	34
2.3	Related Industries	34
2.3.1	Paper Products	34
2.3.2	Petroleum and Coal Products	35
2.3.3	Plastics and Rubber Products	35
2.3.4	Other Related Industries	35
2.4	Top 50 Chemical Companies	36
2.5	Important Chemical Products	40
2.5.1	Sulfuric Acid	40
2.5.2	Caustic Soda and Chlorine	42
2.5.3	Nitrogen and Oxygen	44
2.5.4	Hydrogen and Carbon Dioxide	45
2.5.5	Ammonia	46
2.5.6	Soda Ash (Sodium Carbonate)	48
2.5.7	Ethylene and Propylene	49
2.5.8	Benzene, Toluene, and Xylenes	49
2.6	Characteristics of Chemical Industries	50
2.7	Summary	53
<b>CHAPTER 3</b>	<b>MAKING OF A CHEMICAL ENGINEER</b>	<b>57</b>
3.1	A Chemical Process Plant: Synthesis of Ammonia	57
3.2	Responsibilities and Functions of a Chemical Engineer	61
3.3	Chemical Engineering Curriculum	63
3.3.1	Advanced Chemical Engineering Courses	63
3.3.2	Fundamental Chemical Engineering Courses	77
3.3.3	Engineering Science Courses	80

3.3.4	Fundamental Science and Mathematics Courses	84
3.3.5	General Education Courses	86
3.4	Summary	87
<b>CHAPTER 4</b>	<b>INTRODUCTION TO COMPUTATIONS IN CHEMICAL ENGINEERING</b>	<b>91</b>
4.1	Nature of Chemical Engineering Computational Problems	91
4.1.1	Algebraic Equations	92
4.1.2	Transcendental Equations	95
4.1.3	Ordinary Differential Equations	97
4.1.4	Partial Differential Equations	99
4.1.5	Integral Equations	100
4.1.6	Regression Analysis and Interpolation	101
4.2	Solution Algorithms	102
4.2.1	Linear Algebraic Equations	103
4.2.2	Polynomial and Transcendental Equations	104
4.2.3	Derivatives and Differential Equations	105
4.2.4	Regression Analysis	106
4.2.5	Integration	106
4.3	Computational Tools—Machines and Software	107
4.3.1	Computational Machines	107
4.3.2	Software	110
4.4	Summary	113
<b>CHAPTER 5</b>	<b>COMPUTATIONS IN FLUID FLOW</b>	<b>117</b>
5.1	Qualitative Description of Flow in Conduits	117
5.1.1	Velocity Profiles in Laminar and Turbulent Flows	118

5.2	Quantitative Analysis of Fluid Flow	119
5.2.1	Energy Balance for Fluid Flow	119
5.2.2	Viscosity	120
5.2.3	Reynolds Number	122
5.2.4	Pressure Drop Across a Flow Conduit	122
5.3	Basic Computational Problems	124
5.4	Summary	140
<b>CHAPTER 6</b>	<b>MATERIAL BALANCE COMPUTATIONS</b>	<b>143</b>
6.1	Quantitative Principles of Material Balance	143
6.1.1	Overall Material Balance	144
6.1.2	Component Material Balance	145
6.2	Material Balances in Nonreacting Systems	146
6.3	Material Balances in Reacting Systems	151
6.4	Material Balances over Multiple Process Units	159
6.5	Summary	163
<b>CHAPTER 7</b>	<b>ENERGY BALANCE COMPUTATIONS</b>	<b>167</b>
7.1	Quantitative Principles of Energy Balance	167
7.1.1	Forms of Energy	168
7.1.2	Generalized Energy Balance	168
7.1.3	Enthalpy and Heat Capacity	170
7.1.4	Enthalpy Changes in Processes	173
7.2	Basic Energy Balance Problems	175
7.3	Summary	186
<b>CHAPTER 8</b>	<b>COMPUTATIONS IN CHEMICAL ENGINEERING THERMODYNAMICS</b>	<b>191</b>
8.1	Fundamental Concepts of Thermodynamics	192
8.1.1	System Definition, Properties, and State	192
8.1.2	Internal Energy and Entropy	193

8.1.3	Enthalpy and Free Energies	194
8.1.4	Property Changes in Transformations	195
8.1.5	Chemical Potential and Equilibrium	197
8.1.6	Volumetric Behavior of Substances	200
8.1.7	Nonideality	203
8.2	Basic Computational Problems	204
8.3	Summary	211
<b>CHAPTER 9</b>	<b>COMPUTATIONS IN CHEMICAL ENGINEERING KINETICS</b>	<b>217</b>
9.1	Fundamental Concepts of Chemical Engineering Kinetics	218
9.1.1	Intrinsic Kinetics and Reaction Rate Parameters	219
9.1.2	Batch and Continuous Reactors	221
9.1.3	Reactor Design	224
9.1.4	Conversion	227
9.1.5	Other Considerations	229
9.2	Basic Computational Problems	229
9.3	Summary	240
<b>EPILOGUE</b>		<b>245</b>
<b>APPENDIX A</b>	<b>INTRODUCTION TO MATHEMATICAL SOFTWARE PACKAGES</b>	<b>247</b>
<b>APPENDIX B</b>	<b>COMPUTATIONS USING PROCESS SIMULATION SOFTWARE</b>	<b>259</b>
<b>INDEX</b>		<b>273</b>