
Table of Contents

Chapter 1	Introduction	1
I.	History of Medical Devices	1
A.	Stethoscopes	4
B.	Microscopes	6
C.	Surgery	7
D.	Defibrillators	10
II.	The Role of Biomedical Engineering Technologists in Healthcare.....	10
III.	Characteristics of Human Anatomy and Physiology That Relate to Medical Devices.....	19
A.	Electrical Signals and Conductivity	19
B.	Circulation	20
C.	Blood.....	27
D.	Respiration.....	28
E.	Chemical Balances	29
F.	Densities	30
G.	Temperature	32
	1. Hypothermia.....	32
	2. Hyperthermia.....	34
IV.	Chapter Summary	34
Chapter 2	Diagnostic Devices — Part One.....	35
I.	Physiological Monitoring Systems	35
A.	Overview.....	35
B.	Integration and Connectivity	35
C.	Central Stations	37
D.	Telemetry	40
II.	The Heart.....	43
A.	ECG Monitors and Machines.....	43
B.	ECG Electrodes	46
C.	Amplifiers	47
D.	Interference	47
	1. Internally Generated Artifacts.....	48
	2. Externally Generated Artifacts.....	48
E.	Filters	49
F.	Lead Arrangements.....	49
G.	Patient Isolation	53

III.	Digital Systems	54
A.	Waveform Analysis and Measurements	54
1.	Alarms	54
2.	Waveform/Event Storage	55
3.	Arrhythmia Analysis	55
B.	Stress Testing	58
1.	Exercise Component	59
2.	Interface.....	60
3.	Controller	61
4.	ECG Monitor.....	62
C.	Ambulatory ECG Recorders/Analysis Systems.....	62
D.	Cardiac Output.....	64
IV.	Chapter Summary	65

Chapter 3	Diagnostic Devices — Part Two.....	67
I.	Circulatory System and Blood.....	67
A.	Introduction.....	67
1.	Hypertension	67
2.	Hypotension	68
B.	Blood Pressure Measurement.....	68
1.	Invasive Blood Pressure Monitors	68
2.	Pressure Transducers.....	69
3.	Noninvasive Blood Pressure Monitors	69
4.	Pressure Measurement Cycle.....	71
5.	Further Notes.....	72
C.	Pulse Oximeters.....	73
D.	Transcutaneous CO ₂ Analyzers	77
E.	Blood Chemistry Analyzers	77
F.	Glucometers	80
G.	Doppler Blood Flow Detectors	82
II.	Respiratory System	83
A.	Pulmonary Function Analyzers	83
1.	Incentive Spirometer	87
2.	Graphing Spirometer.....	87
3.	Pulmonary Function Analyzer	87
B.	Respiration Monitors	87
C.	Capnography Monitors	88
D.	Oxygen Analyzers	90
E.	Bronchoscopy Systems.....	91
III.	Nervous System	92
A.	EEG Monitors and Machines	93
B.	BIS Monitors	95
C.	Muscle/Nerve Stimulators	95
IV.	Chapter Summary	96

Chapter 4	Diagnostic Devices — Part Three	97
I.	Digestive System.....	97
A.	Endoscopes	97
1.	General	97
2.	Types of Endoscopes.....	97
3.	Rigid Endoscopes.....	98
4.	Flexible Endoscopes	99
5.	Other System Components	100
II.	Sensory Organs	107
A.	Oto/Laryngo/Ophthalmoscopes	107
1.	Otoscope.....	108
2.	Laryngoscope	109
3.	Ophthalmoscope.....	109
B.	Slit Lamps.....	110
III.	Reproduction	111
A.	Fetal Heart Detectors.....	111
B.	Fetal Monitors	113
C.	Infant Scales	115
D.	APGAR Timers	115
IV.	Skin, Bone, Muscle, Miscellaneous	117
A.	Thermometers	117
1.	Electronic Probe Thermometers	119
2.	Tympanic Thermometers.....	120
B.	Densitometers	120
C.	Arthroscopy Systems.....	122
V.	Chapter Summary	122
Chapter 5	Diagnostic Imaging	123
I.	Introduction	123
A.	X-Rays	123
1.	History	123
2.	Physics.....	123
3.	Definitions of Units.....	124
4.	Detectors.....	125
5.	Effects and Dosage Limits.....	125
6.	X-Ray Safety	126
7.	X-Ray Procedures	126
B.	Magnetic Resonance Imaging Scanners	133
C.	Positron Emission Tomography	136
D.	Diagnostic Ultrasound.....	137
E.	Picture Archiving and Communication System.....	138
II.	Chapter Summary	139

Chapter 6	Treatment Devices — Part One.....	141
I.	Heart.....	141
A.	Defibrillators	141
1.	History	141
2.	Theory of Operation.....	142
3.	Function.....	144
4.	Defibrillator Types	150
B.	Pacemakers	157
1.	History	157
2.	Theory of Operation.....	158
3.	Construction	160
4.	Application	160
5.	External Pacemakers	160
II.	Circulatory System and Blood.....	161
A.	Artificial Hearts	161
B.	Ventricular Assist Devices.....	161
C.	Intraaortic Balloon Pumps.....	161
D.	Heart-Lung Machines.....	162
E.	Sequential Compression Devices	163
F.	Automatic Tourniquets	163
G.	Blood Warmers	163
H.	Intravenous Fluid Administration Pumps	164
1.	Pressure Infusers	166
2.	Fluid Controllers	166
3.	Syringe Pumps	166
4.	Piston Pumps.....	168
5.	Peristaltic Pumps.....	168
6.	Patient-Controlled Analgesia Pumps	170
7.	Safety Features of IV Pumps.....	172
III.	Respiratory System	174
A.	Ventilators	174
B.	CPAP/BiPAP Units	179
C.	Oxygen Concentrators	179
D.	Humidifiers	180
VI.	Chapter Summary	181
Chapter 7	Treatment Devices — Part Two.....	183
I.	Nervous System	183
A.	Anesthesia.....	183
1.	Anesthetic Agents	183
2.	Anesthetic Machines	184
3.	Anesthesia Vaporizers	185
B.	Anesthetic Gas Monitors.....	187
C.	Electroconvulsive Therapy Machines	188

II.	Digestive System.....	189
A.	Feeding Pumps	189
III.	Renal System.....	191
A.	Hemodialysis	192
1.	Water Purification System.....	193
2.	Access Point.....	193
3.	Monitoring Components	194
4.	Dialyzer	194
B.	Peritoneal Dialysis.....	195
C.	Lithotriptors	196
IV.	Sensory Organs	198
A.	Phacoemulsifiers	198
B.	Ophthalmic Lasers.....	200
V.	Chapter Summary	202

Chapter 8	Treatment Devices — Part Three	203
I.	Reproductive System	203
A.	Bilirubin Therapy Systems.....	203
B.	Infant Incubators.....	205
C.	Infant Resuscitators	208
D.	Nitrous Oxide Units	209
II.	Skin, Bone, Muscle, and Miscellaneous	211
A.	Electrosurgery Machines	211
1.	Monopolar Electrosurgery	213
2.	Bipolar Electrosurgery	215
B.	Surgical Lasers	216
1.	Carbon Dioxide Lasers	216
2.	Neodymium-Doped Yttrium Aluminium Garnet Lasers	217
3.	Argon Lasers	217
4.	Excimer Lasers.....	217
5.	Laser Safety.....	217
C.	Surgical Ultrasound	218
D.	Cryosurgery Units	218
E.	Microscopes.....	220
F.	Sterilizers	221
1.	Gas Sterilizers	221
2.	Heat Sterilizers	222
3.	Liquid Sterilizers.....	223
G.	Physiotherapy Equipment.....	225
1.	Continuous Passive Motion	225
2.	Pain Relief.....	226
3.	Promotion of Healing.....	228
III.	Chapter Summary	230

Chapter 9	BMET Work	231
I.	Overview	231
II.	Electrical Safety	231
A.	Rationale	232
B.	Testing Methods	233
III.	Other Safety Considerations	234
A.	Fire Safety	234
B.	Chemical Safety.....	235
C.	Mechanical Safety	236
D.	Infection Control	236
E.	Sharps Safety	238
IV.	Performance Assurance.....	238
V.	Troubleshooting Techniques	243
VI.	Electrostatic Discharge.....	247
VII.	Chapter Summary	247
Chapter 10	Testers and Tools	249
I.	Introduction	249
II.	General Test Equipment.....	249
A.	Digital Multimeters	249
B.	Oscilloscopes	250
C.	Other Test Equipment.....	252
III.	Specialized Biomedical Test Equipment	253
A.	ESU Analyzers.....	253
B.	Infusion Device Analyzers	255
C.	Physiological Simulators	255
D.	NIBP Analyzers	256
E.	Ventilator Analyzers	258
F.	Incubator Analyzers.....	258
G.	Ultrasound Analyzers	259
H.	Specialized Calibration and Testing Devices.....	259
IV.	Tools	261
A.	General.....	261
B.	Specialized Tools and Components	262
C.	Power Tools	263
V.	Soldering	263
VI.	Other.....	265
VII.	Chapter Summary	265
Chapter 11	Batteries, Radiation, and Computers	267
I.	Batteries.....	267
A.	Nonrechargeable Batteries.....	268
1.	Alkaline	268

2. Mercury	268
3. Zinc/Air	268
B. Rechargeable Batteries	269
1. Lithium or LiIon	269
2. Nickel Metal Hydride or NiMH	269
3. Nickel Cadmium or NiCad, NiCd	269
4. Lead Acid	270
C. Battery Analyzers	270
D. Battery Disposal	272
II. Electromagnetic Radiation.....	272
III. Digital Electronics.....	273
A. Introduction.....	273
B. Digital Signals	273
C. Binary Numbers.....	274
D. Analog to Digital Conversion	274
E. Microprocessors.....	275
F. Computers and Networks	275
IV. Chapter Summary	277
 Chapter 12 Technology Management.....	 279
I. General Considerations	279
II. Planning.....	279
III. Software.....	279
 Appendix A: Normal Values.....	 281
 Appendix B: Regulations and Standards	 285
 Appendix C: Biomedical Engineering Technology Programs in the US and Canada	 289
 Appendix D: Biomed Associations	 303
 Appendix E: Devices and Manufacturers	 313
 Appendix F: Test Equipment Manufacturers	 315
 Appendix G: Bibliography and Internet Resources.....	 317
 Index	 321