
Contents

Part One

Introduction to Bioengineering and Bioinstrumentation 1

Chapter 1 Biomedical Engineering: An Interdisciplinary Profession 3

- Introduction 3
- The Evolution of the Modern Health Care System 4
 - The Beginnings 4
 - The Modern Health Care System 10
- Biomedical Engineering: Some Definitions 16
- Clinical Engineering Comes of Age 18
- Role of the Biomedical Engineer 22
- References 25

Part Two

Basic Physiology and Biomedical Instrumentation Devices 27

Chapter 2 Biosensors: Transducers, Electrodes, and Physiological Systems 29

- Introduction 29
- Physiological Systems: General Classifications 31
 - Nervous System 31
 - Cardiovascular System 32
 - Respiratory System 32
 - Endocrine System 32
 - Gastrointestinal System 32
 - Urogenital System 32
 - Musculoskeletal System 33
 - Hematopoietic System 33

Integumental System	33
Basic Physiological Measurements and Techniques	33
Physical Transducers	34
Chemical Sensors	57
New Technologies of Biosensors	70
References	75

Part Three

Instrumentation Systems

77

Chapter 3 Cardiovascular Assist and Monitoring Devices 79

Introduction	79
Fundamental Principles of Heart Action	80
Cardiac Monitoring and Assist Instrumentation	84
Cardiac Pacemakers	84
Defibrillators	87
Cardiac Monitors	90
The Artificial Heart and Assist Devices	96
References	103

Chapter 4 Pulmonary Assist and Measurement Devices 106

Introduction	104
Pulmonary Physiology	107
The Pulmonary Function Laboratory	109
Spirometry	110
Body Plethysmography	115
Diffusing Capacity	117
Respiratory Therapy	118
Respiratory Intensive Care	127
Extracorporeal Membrane Oxygenation	132
References	136

Chapter 5 Neurophysiological Measurements 138

Introduction	138
Basic Neuroanatomy and Neurophysiology	139
Overview of the Primary Structures	139
Central Nervous System	140
Peripheral Nervous System	145
Origin and Characteristics of Nervous System Potentials	147
Single Unit Potentials: The Action Potential	147
Volume Conductor Potential	148
Measurement Techniques and Systems	153
Single Cell and Multiunit Recordings	153
Electroencephalography Techniques	159

Advanced EEG Systems	159
Evoked Response Recording Techniques	165
Clinical Applications	169
Nerve Conduction Velocities	170
EEG Applications	171
Evoked Potential Applications	174
References	176

Chapter 6 **Musculoskeletal Biomechanics: Fundamental Measurements and Analysis** 180

Introduction	180
Measurement Parameters, Methods, and Systems	182
Parameter Specification	182
Methods and Systems	182
Newington Children's Hospital Gait Analysis Laboratory	191
Methods of Analysis	195
Newtonian Mechanics	195
Kinematics	196
Newtonian Statics and Dynamics	205
Assessment	216
References	218

Part Four

Computer Technology: Medical Applications 223

Chapter 7 **Computers and Medical Instrumentation** 225

Introduction	225
Basic Computer Concepts	226
The Digital Computer	228
Binary Number System	228
Coding in Binary	230
Binary Logic: Hardware	231
The Process of Computer Programming: The Software	236
Computer Languages	237
The Microcomputer	240
Computer Operation: Hardware and Software Interaction	242
Computers in the Clinical Laboratory	246
Hematology	247
Clinical Chemistry	251
Computerization Concepts in the Clinical Laboratory	258
Computerized Patient Monitoring	265
Physiological Monitoring	266
References	274

Part Five

Diagnostic Support Systems

277

Chapter 8 Basic Science and Practice of Nuclear Medicine 279

- Introduction 279
- Basic Concepts of Nuclear Medicine 281
 - Elementary Particles 282
 - Radionuclides and Radiopharmacy 290
 - Radiation Interaction and Dosimetry 295
 - Instrumentation and Imaging Devices 300
- Clinical Application of Nuclear Medical Techniques 307
 - Lungs 308
 - Liver and Spleen 312
 - Radiocolloid 315
 - Tumors and Infections 318
 - Endocrine System 320
 - Skeletal System 327
 - Urinary System 331
 - Central Nervous System 335
 - Evaluation of the Heart 337
 - Summary of Clinical Studies 341
 - Future Development 341
- References 345

Chapter 9 Principles of Diagnostic Ultrasound 347

- Introduction 347
- Physical Properties 349
- Ultrasound Propagation 351
- Attenuation 354
- Transducer 355
- Doppler Flowmeter 357
- Doppler Circuitry 360
- Transit-time Pulsed-sonic Flowmeter 363
- Ultrasonic Scanner Modes 365
- Pulsed Doppler Systems 367
- Spectral Analysis of Doppler Velocity Signals 368
- Real-time Scanners 371
- An Ultrasound Imaging System 375
- Critical Applications of Real Time Scanners 378
- Future of Ultrasonic Imaging 382
- References 384

Chapter 10 Radiographic and Nuclear Magnetic Resonance Imaging 387

- Introduction 387
- Radiographic (X-ray) Imaging Systems 388

Types of X-ray Imaging Systems	388
X-ray Image Formation	389
X-ray Image Quality	392
Projection Radiography Systems	399
Fluoroscopic Radiography Systems	404
Motion Tomography Systems	407
Computerized Axial Tomography (CAT) Scanners	408
Nuclear Magnetic Resonance Imaging (NMR) Systems	418
NMR Operating Principles	418
NMR Image Formation	421
NMR Image Quality	424
Comparison of CAT Scanners and NMR Imaging Systems	425
Future Perspectives in NMR Imaging	427
References	429

Part Six

Medical Technology and Ethical Issues

431

Chapter 11 The Moral and Ethical Aspects of Technology in Medicine 433

Introduction	433
Morality and Ethics: A Definition of Terms	434
Definition of Death	439
The Critically Ill Patient and Euthanasia	445
Human Experimentation	452
Definition and Purpose of Experimentation	453
Fetal Research	460
Organ Transplantation	463
References	468

Index 471