

## Table of Contents

- Preface p. xv
- Acknowledgments p. xvii
- Foreword p. xix
- Section I Basic Concepts p. 1
- Chapter 1 Introduction to Medical Imaging p. 3
  - 1.1 The Modalities p. 4
  - 1.2 Image Properties p. 13
- Chapter 2 Radiation and the Atom p. 17
  - 2.1 Radiation p. 17
  - 2.2 Structure of the Atom p. 21
- Chapter 3 Interaction of Radiation with Matter p. 31
  - 3.1 Particle Interactions p. 31
  - 3.2 X- and Gamma Ray Interactions p. 37
  - 3.3 Attenuation of X- and Gamma Rays p. 45
  - 3.4 Absorption of Energy from X- and Gamma Rays p. 52
  - 3.5 Imparted Energy, Equivalent Dose, and Effective Dose p. 56
- Chapter 4 Computers in Medical Imaging p. 61
  - 4.1 Storage and Transfer of Data in Computers p. 61
  - 4.2 Analog Data and Conversion between Analog and Digital Forms p. 66
  - 4.3 Components and Operation of Computers p. 70
  - 4.4 Performance of Computer Systems p. 78
  - 4.5 Computer Software p. 79
  - 4.6 Storage, Processing, and Display of Digital Images p. 82
- Section II Diagnostic Radiology p. 95
- Chapter 5 X-ray Production, X-ray Tubes, and Generators p. 97
  - 5.1 Production of X-rays p. 97
  - 5.2 X-ray Tubes p. 102
  - 5.3 X-ray Tube Insert, Tube Housing, Filtration, and Collimation p. 113
  - 5.4 X-ray Generator Function and Components p. 116
  - 5.5 X-ray Generator Circuit Designs p. 124
  - 5.6 Timing the X-ray Exposure in Radiography p. 132
  - 5.7 Factors Affecting X-ray Emission p. 135
  - 5.8 Power Ratings and Heat Loading p. 137
  - 5.9 X-ray Exposure Rating Charts p. 140
- Chapter 6 Screen-Film Radiography p. 145
  - 6.1 Projection Radiography p. 145
  - 6.2 Basic Geometric Principles p. 146
  - 6.3 The Screen-Film Cassette p. 148
  - 6.4 Characteristics of Screens p. 149
  - 6.5 Characteristics of Film p. 157
  - 6.6 The Screen-Film System p. 163
  - 6.7 Contrast and Dose in Radiography p. 164
  - 6.8 Scattered Radiation in Projection Radiography p. 166
- Chapter 7 Film Processing p. 175

- 7.1 Film Exposure p. 175
- 7.2 The Film Processor p. 178
- 7.3 Processor Artifacts p. 181
- 7.4 Other Considerations p. 183
- 7.5 Laser Cameras p. 184
- 7.6 Dry Processing p. 184
- 7.7 Processor Quality Assurance p. 186
- Chapter 8 Mammography p. 191
- 8.1 X-ray Tube Design p. 194
- 8.2 X-ray Generator and Phototimer System p. 204
- 8.3 Compression, Scattered Radiation, and Magnification p. 207
- 8.4 Screen-Film Cassettes and Film Processing p. 212
- 8.5 Ancillary Procedures p. 219
- 8.6 Radiation Dosimetry p. 222
- 8.7 Regulatory Requirements p. 224
- Chapter 9 Fluoroscopy p. 231
- 9.1 Functionality p. 231
- 9.2 Fluoroscopic Imaging Chain Components p. 232
- 9.3 Peripheral Equipment p. 242
- 9.4 Fluoroscopy Modes of Operation p. 244
- 9.5 Automatic Brightness Control (ABC) p. 246
- 9.6 Image Quality p. 248
- 9.7 Fluoroscopy Suites p. 249
- 9.8 Radiation Dose p. 251
- Chapter 10 Image Quality p. 255
- 10.1 Contrast p. 255
- 10.2 Spatial Resolution p. 263
- 10.3 Noise p. 273
- 10.4 Detective Quantum Efficiency (DQE) p. 283
- 10.5 Sampling and Aliasing in Digital Images p. 283
- 10.6 Contrast-Detail Curves p. 287
- 10.7 Receiver Operating Characteristics Curves p. 288
- Chapter 11 Digital Radiography p. 293
- 11.1 Computed Radiography p. 293
- 11.2 Charged-Coupled Devices (CCDs) p. 297
- 11.3 Flat Panel Detectors p. 300
- 11.4 Digital Mammography p. 304
- 11.5 Digital versus Analog Processes p. 307
- 11.6 Implementation p. 307
- 11.10 Contrast versus Spatial Resolution in Digital Imaging p. 315
- 11.7 Patient Dose Considerations p. 308
- 11.8 Hard Copy versus Soft Copy Display p. 308
- 11.9 Digital Image Processing p. 309
- Chapter 12 Adjuncts to Radiology p. 317
- 12.1 Geometric Tomography p. 317
- 12.2 Digital Tomosynthesis p. 320

- 12.3 Temporal Subtraction p. 321
- 12.4 Dual-Energy Subtraction p. 323
- Chapter 13 Computed Tomography p. 327
- 13.1 Basic Principles p. 327
- 13.2 Geometry and Historical Development p. 331
- 13.3 Detectors and Detector Arrays p. 339
- 13.4 Details of Acquisition p. 342
- 13.5 Tomographic Reconstruction p. 346
- 13.6 Digital Image Display p. 358
- 13.7 Radiation Dose p. 362
- 13.8 Image Quality p. 367
- 13.9 Artifacts p. 369
- Chapter 14 Nuclear Magnetic Resonance p. 373
- 14.1 Magnetization Properties p. 373
- 14.2 Generation and Detection of the Magnetic Resonance Signal p. 381
- 14.3 Pulse Sequences p. 391
- 14.4 Spin Echo p. 391
- 14.5 Inversion Recovery p. 399
- 14.6 Gradient Recalled Echo p. 403
- 14.7 Signal from Flow p. 408
- 14.8 Perfusion and Diffusion Contrast p. 409
- 14.9 Magnetization Transfer Contrast p. 411
- Chapter 15 Magnetic Resonance Imaging (MRI) p. 415
- 15.1 Localization of the MR Signal p. 415
- 15.2 k-space Data Acquisition and Image Reconstruction p. 426
- 15.3 Three-Dimensional Fourier Transform Image Acquisition p. 438
- 15.4 Image Characteristics p. 439
- 15.5 Angiography and Magnetization Transfer Contrast p. 442
- 15.6 Artifacts p. 447
- 15.7 Instrumentation p. 458
- 16.2 Interactions of Ultrasound with Matter p. 476
- 15.8 Safety and Bioeffects p. 465
- Chapter 16 Ultrasound p. 469
- 16.1 Characteristics of Sound p. 470
- 16.3 Transducers p. 483
- 16.4 Beam Properties p. 490
- 16.5 Image Data Acquisition p. 501
- 16.6 Two-Dimensional Image Display and Storage p. 510
- 16.7 Miscellaneous Issues p. 516
- 16.8 Image Quality and Artifacts p. 524
- 16.9 Doppler Ultrasound p. 531
- 16.10 System Performance and Quality Assurance p. 544
- 16.11 Acoustic Power and Bioeffects p. 548
- Chapter 17 Computer Networks, PACS, and Teleradiology p. 555
- 17.1 Computer Networks p. 555
- 17.2 PACS and Teleradiology p. 565

- Section III Nuclear Medicine p. 587
- Chapter 18 Radioactivity and Nuclear Transformation p. 589
- 18.1 Radionuclide Decay Terms and Relationships p. 589
- 18.2 Nuclear Transformation p. 593
- Chapter 19 Radionuclide Production and Radiopharmaceuticals p. 603
- 19.1 Radionuclide Production p. 603
- 19.2 Radiopharmaceuticals p. 617
- 19.3 Regulatory Issues p. 624
- Chapter 20 Radiation Detection and Measurement p. 627
- 20.1 Types of Detectors p. 627
- 20.2 Gas-Filled Detectors p. 632
- 20.3 Scintillation Detectors p. 636
- 20.4 Semiconductor Detectors p. 641
- 20.5 Pulse Height Spectroscopy p. 644
- 20.6 Non-Imaging Detector Applications p. 654
- 20.7 Counting Statistics p. 661
- Chapter 21 Nuclear Imaging--The Scintillation Camera p. 669
- 21.1 Planar Nuclear Imaging: The Anger Scintillation Camera p. 670
- 21.2 Computers in Nuclear Imaging p. 695
- Chapter 22 Nuclear Imaging--Emission Tomography p. 703
- 22.1 Single Photon Emission Computed Tomography (SPECT) p. 704
- 22.2 Positron Emission Tomography (PET) p. 719
- Section IV Radiation Protection, Dosimetry, and Biology p. 737
- Chapter 23 Radiation Protection p. 739
- 23.1 Sources of Exposure to Ionizing Radiation p. 739
- 23.2 Personnel Dosimetry p. 747
- 23.3 Radiation Detection Equipment in Radiation Safety p. 753
- 23.4 Radiation Protection and Exposure Control p. 755
- 23.5 Regulatory Agencies and Radiation Exposure Limits p. 788
- Chapter 24 Radiation Dosimetry of the Patient p. 795
- 24.1 X-ray Dosimetry p. 800
- 24.2 Radiopharmaceutical Dosimetry: The MIRD Method p. 805
- Chapter 25 Radiation Biology p. 813
- 25.1 Interaction of Radiation with Tissue p. 814
- 25.2 Cellular Radiobiology p. 818
- 25.3 Response of Organ Systems to Radiation p. 827
- 25.4 Acute Radiation Syndrome p. 831
- 25.5 Radiation-Induced Carcinogenesis p. 838
- 25.6 Hereditary Effects of Radiation Exposure p. 851
- 25.7 Radiation Effects In Utero p. 853
- A.2 Classical Physics p. 867
- Section V Appendices p. 863
- Appendix A Fundamental Principles of Physics p. 865
- A.1 Physical Laws, Quantities, and Units p. 865
- A.3 Electricity and Magnetism p. 868

- Appendix B Physical Constants, Prefixes, Geometry, Conversion Factors, and Radiologic Data p. 883
- B.1 Physical Constants, Prefixes, and Geometry p. 883
- B.2 Conversion Factors p. 884
- B.3 Radiological Data for Elements 1 through 100 p. 885
- Appendix C Mass Attenuation Coefficients and Spectra Data Tables p. 887
- C.1 Mass Attenuation Coefficients for Selected Elements p. 887
- C.2 Mass Attenuation Coefficients for Selected Compounds p. 889
- C.3 Mass Energy Attenuation Coefficients for Selected Detector Compounds p. 890
- C.4 Mammography Spectra: Mo/Mo p. 891
- C.5 Mammography Spectra: Mo/Rh p. 893
- D.1 Route of administration, localization, clinical utility, and other characteristics of commonly used radiopharmaceuticals p. 900
- C.6 Mammography Spectra: Rh/Rh p. 895
- C.7 General Diagnostic Spectra: W/Al p. 897
- Appendix D Radiopharmaceutical Characteristics and Dosimetry p. 899
- D.2 Typical administered adult activity, highest organ dose, gonadal dose, and adult effective dose for commonly used radiopharmaceuticals p. 908
- D.3 Effective doses per unit activity administered to patients age 15, 10, 5, and 1 year for commonly used diagnostic radiopharmaceuticals p. 910
- D.4 Absorbed dose estimates to the embryo/fetus per unit activity administered to the mother for commonly used radiopharmaceuticals p. 911
- Appendix E Internet Resources p. 913
- Subject Index p. 915