

Table of Contents

	Page
Preface	v
Chapter 1. Radiation	1
1.1 Medical Use of Radiation	1
1.2 Nature of Radiation	4
1.3 Quantum Nature of Radiation	6
1.4 Electromagnetic Radiation Spectrum	10
1.5 Particulate Radiation	12
1.6 Identification of Radiation Types	14
1.7 Radiological Quantities and Units	15
1.8 Sources of Radiation	17
1.9 Effects of Ionizing Radiation	18
1.10 Safe Handling of Radiation and Sources	20
1.11 Historical Perspectives of Radiological Physics	21
1.12 Branches of Physics in Medicine	22
Chapter 2. Mathematics I	29
2.1 Notations	29
2.2 Numbers	30
2.3 Arithmetic Operations	32
2.4 Fractions	33
2.5 Exponents	35
2.6 Roots and Radicals	37
2.7 Logarithms	38
2.8 Ratios and Proportions	40
2.9 Scientific Notation	42
2.10 Significant Figures	43
2.11 Rounding Off Numbers	44
2.12 Electronic Calculators	45

Table of Contents

Chapter 3. Mathematics II	51
3.1 Algebra	51
3.2 Functions	52
3.3 Equations	54
3.4 Quadratic Equations	55
3.5 Angles	56
3.6 Pythagorean Theorem	58
3.7 Analytic Geometry	59
3.8 Solid Geometry	61
3.9 Geometric Functions	62
3.10 Trigonometry	63
3.11 Tables	66
3.12 Graphs	67
3.13 Statistics	70
3.14 Linear Regression	75
3.15 Calculus	76
Chapter 4. General Physics I	87
4.1 Physical Quantities and Units	87
4.2 Measurements, Uncertainties, and Magnitudes	89
4.3 Vectors	91
4.4 Rectilinear Motion	95
4.5 Motion in Two Dimensions	97
4.6 Newton's Law of Motion	99
4.7 Circular Motion	102
4.8 Newton's Law of Universal Gravitation	105
4.9 Work and Energy	107
4.10 Momentum	111
4.11 Rigid Bodies	113
4.12 Stress and Strain	117
4.13 Pressure	118
4.14 Temperature	120
4.15 Heat	122
4.16 Oscillatory Motion and Waves	125
4.17 Sound	129
Chapter 5. General Physics II	143
5.1 Properties of Electric Charges	143
5.2 Coulomb's Law	144
5.3 Electrical Fields	147
5.4 Insulators and Conductors	149
5.5 Gauss's Law	150
5.6 Electric Potential and Energy	151
5.7 Capacitance	156
5.8 Electric Currents	160
5.9 Resistance	163

Foundation of Radiological Physics

5.10	Electromotive Force	164
5.11	Kirchhoff's Rules	165
5.12	RC Circuits	167
5.13	Electrical Measuring Instruments	169
5.14	Magnetism	170
5.15	Currents and Magnetic Fields	172
5.16	Ampere's Law	175
5.17	Hysteresis	177
5.18	Electromagnetic Induction	178
5.19	Transformers	181
5.20	Inductance	182
5.21	LR Circuits	183
5.22	Alternating Current Circuits	183
5.23	Maxwell's Equations	189
5.24	Electromagnetic Waves	190
Chapter 6. Atomic Structure		203
6.1	Matter, Elements, and Atom	203
6.2	Concepts of the Atom	204
6.3	Atomic Models	205
6.4	Bohr's Model of the Hydrogen Atom	208
6.5	Atomic Spectra	211
6.6	Shell Structure of Electrons	212
6.7	Arrangement of Electrons in an Atom	214
6.8	Periodic Table	216
6.9	Binding Energies of Electrons	218
6.10	Transitions Between Energy-States	219
6.11	Auger Electrons	220
6.12	Molecules	221
6.13	Lasers	223
6.14	Heisenberg Uncertainty Principles	224
Chapter 7. Nuclear Structure		231
7.1	Nuclear Nomenclature	231
7.2	Nuclear Force	233
7.3	Nuclear Stability	234
7.4	Trilinear Chart of Nuclides	235
7.5	Atomic Mass Units	236
7.6	Binding Energy of the Nucleus	238
7.7	Nuclear Models	240
Chapter 8. Radioactivity		249
8.1	Radioactivity Decay Law	249
8.2	Half Life	251
8.3	Unit of Radioactivity	254
8.4	Cumulative Activity	256

Table of Contents

8.5	Radioactivity Curve	258
8.6	Natural Occurring Radionuclides and Decaying Series	262
Chapter 9.	Nuclear transformations	273
9.1	Modes of Decay	274
9.2	Energy Level Diagram	276
9.3	Alpha Decay	277
9.4	Negatron Decay	279
9.5	Positron Decay	281
9.6	Electron Capture	283
9.7	Gamma Emission	284
9.8	Internal Conversion	286
9.9	Competitive Modes of Decay	288
9.10	Radionuclides Used in Medicine	289
Chapter 10.	Nuclear reactions	295
10.1	Cross Section	295
10.2	Nuclear Fission	296
10.3	Nuclear Fusion	298
10.4	Nuclear Reactions	300
10.5	Radionuclide Production	302
10.6	Reactor-Produced Radionuclides	302
10.7	Equation of Neutron Activation in a Reactor	303
10.8	Accelerator- or Cyclotron-Produced Radionuclides	304
10.9	Fission-Produced Radionuclides	305
10.10	Radionuclide Generator	306
Chapter 11.	Interaction of radiation with matter	311
11.1	Interaction of Photons with Matter	311
11.2	Coherent Scattering	314
11.3	Photoelectric Effect	315
11.4	Compton Scattering	316
11.5	Pair and Triplet Production	320
11.6	Photodisintegration	321
11.7	Interaction of Heavy Charged Particles with Matter ...	321
11.8	Interaction of Electrons with Matter	323
11.9	Linear Energy Transfer	324
11.10	Interaction of Neutrons	325
11.11	Linear Attenuation Coefficient	326
11.12	Total Attenuation Coefficients	329
11.13	Differential Absorption of Photon Beam	330
11.14	Deposition of Energy in Matter	331
Chapter 12.	Computer Concepts	339
12.1	Computers	339
12.2	Analog and Digital Converters	340

Foundation of Radiological Physics

12.3	Computer Hardware	341
12.4	Computer System Unit	342
12.5	Peripheral Devices	344
12.6	Number Systems Used in Computers	345
12.7	Logic Operations	346
12.8	Bits, Bytes, and Words	350
12.9	Computer Memory	351
12.10	Data Storage Media	354
12.11	File Structure	356
12.12	Computer Programs	357
12.13	Computer Languages	358
12.14	Processing Methods	359
12.15	Networking	360
12.16	History of Computers	361
Chapter 13.	Health Physics I	371
13.1	Equivalent Dose	371
13.2	Environmental Radiation	373
13.3	Radiation Advisory Boards	375
13.4	States and Federal Regulatory Agencies	380
13.5	Radiation Detection Instruments	382
13.6	Personnel Monitoring	387
13.7	Minimizing Exposure from External Sources	390
13.8	Exposure from Sealed Sources	392
13.9	Radioactive Contamination	395
13.10	Loss or Rupture of Sealed Sources	396
13.11	Instructions to Allied Medical Workers	397
13.12	Radiation Emergencies	398
Chapter 14.	Health Physics II	405
14.1	Restricted Areas and Radiation Signs	405
14.2	Storage of Radioactive Materials	408
14.3	Disposal of Radioactive Waste	410
14.4	Radioactive Material Package Shipment	411
14.5	Radiation from Brachytherapy Procedures	412
14.6	Radiation from Therapeutic Radioiodine	415
14.7	Barrier Structure Calculations	416
14.8	Design of Diagnostic Equipment Room	420
14.9	Design of Radiotherapy Equipment Room	422
14.10	Radioactive Sources Shielding	425
14.11	Radiation Protection Surveys	426
14.12	Quality Management Program	428
14.13	Compliance with Regulations	430

Table of Contents

Chapter 15. Radiobiology	439
15.1 Composition of Cells	440
15.2 Atomic and Molecular Events	441
15.3 Free Radicals	442
15.4 Linear Energy Transfer	444
15.5 Cell Proliferation	445
15.6 Law of Bergonie and Tribondeau	449
15.7 Radiosensitivity of Cells	449
15.8 Cell Survival Curve	450
15.9 Relative Biologic Effectiveness	455
15.10 Repair of Radiation Damage	456
15.11 Acute Radiation Effects	458
15.12 Dose Response Relationships	460
15.13 Late Effects of Radiation	461
15.14 Hereditary Effects	463
15.15 Embryonic and Fetal Effects	465
15.16 Factors Influencing Radiosensitivity	466
15.17 Tumor Biology	469
15.18 Fractionation	470
15.19 Dose Rate Effect	472
15.20 Isoeffect Curves	474
15.21 Applications to Radiotherapy	478
Appendix	
Appendix A Greek Letters	488
Appendix B SI Prefixes	489
Appendix C Fundamental Constants	490
Appendix D US Units Conversion Factors	491
Appendix E Metric Units Conversion Facotors	492
Appendix F US to Metric Units Conversions	493
Appendix G Metric to US Units Conversions	494
Appendix H Elements	495
Appendix I Decay Chart of Iodine-125	496
Appendix J Decay Chart of Iridium-192	497
Appendix K American National Standard Code for Information Interchange (ASCII)	498
Appendix L Logic Symbols and Truth Tables	499
Solution to Problems	501
Bibliography	505
Index	511