

Part I Fundamental Basics

1	Dimensions and Units	3
1.1	The International System of Units	3
1.2	Standards of Length, Time, and Mass	5
1.3	Dimensional Analysis	9
1.4	Exercises	12
2	Vectors	17
2.1	Vectors and Scalars	17
2.2	Properties of Vectors	19
2.3	Vector Components and Unit Vectors	22
2.4	Multiplying Vectors	27
2.5	Exercises	33

Part II Mechanics

3	Motion in One Dimension	41
3.1	Position and Displacement	41
3.2	Average Velocity and Average Speed	42
3.3	Instantaneous Velocity and Speed	44
3.4	Acceleration	48
3.5	Constant Acceleration	52
3.6	Free Fall	57
3.7	Exercises	62
4	Motion in Two Dimensions	71
4.1	Position, Displacement, Velocity, and Acceleration Vectors	71
4.2	Projectile Motion	79

4.3	Uniform Circular Motion	87
4.4	Tangential and Radial Acceleration	90
4.5	Non-uniform Circular Motion	91
4.6	Exercises	93
5	Force and Motion	103
5.1	The Cause of Acceleration and Newton's Laws	103
5.2	Some Particular Forces	106
5.3	Applications to Newton's Laws	113
5.4	Exercises	124
6	Work, Energy, and Power	137
6.1	Work Done by a Constant Force	137
6.2	Work Done by a Variable Force	142
6.3	Work-Energy Theorem	148
6.4	Conservative Forces and Potential Energy	151
6.5	Conservation of Mechanical Energy	157
6.6	Work Done by Non-conservative Forces	159
6.7	Conservation of Energy	162
6.8	Power	166
6.9	Exercises	170
7	Linear Momentum, Collisions, and Center of Mass	181
7.1	Linear Momentum and Impulse	181
7.2	Conservation of Linear Momentum	184
7.3	Conservation of Momentum and Energy in Collisions	187
7.3.1	Elastic Collisions in One and Two Dimensions	187
7.3.2	Inelastic Collisions	194
7.4	Center of Mass (CM)	195
7.5	Dynamics of the Center of Mass	199
7.6	Systems of Variable Mass	203
7.6.1	Systems of Increasing Mass	204
7.6.2	Systems of Decreasing Mass; Rocket Propulsion	205
7.7	Exercises	209
8	Rotational Motion	227
8.1	Radian Measures	227
8.2	Rotational Kinematics; Angular Quantities	228
8.3	Constant Angular Acceleration	232
8.4	Angular Vectors	233
8.5	Relating Angular and Linear Quantities	233
8.6	Rotational Dynamics; Torque	238
8.7	Newton's Second Law for Rotation	240
8.8	Kinetic Energy, Work, and Power in Rotation	248

8.9	Rolling Motion	252
8.10	Exercises	259
9	Angular Momentum	269
9.1	Angular Momentum of Rotating Systems	269
9.1.1	Angular Momentum of a Particle	269
9.1.2	Angular Momentum of a System of Particles	271
9.1.3	Angular Momentum of a Rotating Rigid Body	271
9.2	Conservation of Angular Momentum	277
9.3	The Spinning Top and Gyroscope	285
9.4	Exercises	289
10	Mechanical Properties of Matter	303
10.1	Density and Relative Density	304
10.2	Elastic Properties of Solids	306
10.2.1	Young's Modulus: Elasticity in Length	307
10.2.2	Shear Modulus: Elasticity of Shape	310
10.2.3	Bulk Modulus: Volume Elasticity	312
10.3	Fluids	314
10.4	Fluid Statics	316
10.5	Fluid Dynamics	328
10.6	Exercises	345
 Part III Introductory Thermodynamics		
11	Thermal Properties of Matter	357
11.1	Temperature	357
11.2	Thermal Expansion of Solids and Liquids	360
11.2.1	Linear Expansion	361
11.2.2	Volume Expansion	362
11.3	The Ideal Gas	365
11.4	Exercises	371
12	Heat and the First Law of Thermodynamics	379
12.1	Heat and Thermal Energy	379
12.1.1	Units of Heat, The Mechanical Equivalent of Heat	379
12.1.2	Heat Capacity and Specific Heat	380
12.1.3	Latent Heat	384
12.2	Heat and Work	390
12.3	The First Law of Thermodynamics	395
12.4	Applications of the First Law of Thermodynamics	396
12.5	Heat Transfer	406
12.6	Exercises	416

13	Kinetic Theory of Gases	427
13.1	Microscopic Model of an Ideal Gas	427
13.2	Molar Specific Heat Capacity of an Ideal Gas	434
13.2.1	Molar Specific Heat at Constant Volume	435
13.2.2	Molar Specific Heat at Constant Pressure	436
13.3	Distribution of Molecular Speeds	441
13.4	Non-ideal Gases and Phases of Matter	442
13.5	Exercises	444
 Part IV Sound and Light Waves		
14	Oscillations and Wave Motion	451
14.1	Simple Harmonic Motion	451
14.1.1	Velocity and Acceleration of SHM	452
14.1.2	The Force Law for SHM	455
14.1.3	Energy of the Simple Harmonic Oscillator	459
14.2	*Damped Simple Harmonic Motion	462
14.3	Sinusoidal Waves	463
14.3.1	Transverse and Longitudinal Waves	463
14.3.2	Wavelength and Frequency	465
14.3.3	Harmonic Waves: Simple Harmonic Motion	466
14.4	The Speed of Waves on Strings	470
14.5	Energy Transfer by Sinusoidal Waves on Strings	472
14.6	The Linear Wave Equation	476
14.7	Standing Waves	477
14.7.1	Reflection at a Boundary	481
14.7.2	Standing Waves and Resonance	482
14.8	Exercises	486
15	Sound Waves	499
15.1	Speed of Sound Waves	499
15.2	Periodic Sound Waves	502
15.3	Energy, Power, and Intensity of Sound Waves	505
15.4	The Decibel Scale	510
15.5	Hearing Response to Intensity and Frequency	514
15.6	The Doppler Effect	514
15.7	Supersonic Speeds and Shock Waves	521
15.8	Exercises	523
16	Superposition of Sound Waves	531
16.1	Superposition and Interference	531
16.2	Spatial Interference of Sound Waves	533
16.3	Standing Sound Waves	537
16.4	Standing Sound Waves in Air Columns	541

16.5	Temporal Interference of Sound Waves: Beats	549
16.6	Exercises	554
17	Light Waves and Optics	561
17.1	Light Rays	561
17.2	Reflection and Refraction of Light	563
17.3	Total Internal Reflection and Optical Fibers	568
17.4	Chromatic Dispersion and Prisms	571
17.5	Formation of Images by Reflection	575
	17.5.1 Plane Mirrors	575
	17.5.2 Spherical Mirrors	576
17.6	Formation of Images by Refraction	583
	17.6.1 Spherical Refracting Surfaces	583
	17.6.2 Flat Refracting Surfaces	584
	17.6.3 Thin Lenses	586
17.7	Exercises	595
18	Interference, Diffraction and Polarization of Light	603
18.1	Interference of Light Waves	603
18.2	Young's Double Slit Experiment	604
18.3	Thin Films—Change of Phase Due to Reflection	611
18.4	Diffraction of Light Waves	615
18.5	Diffraction Gratings	620
18.6	Polarization of Light Waves	624
18.7	Exercises	627
Part V Electricity		
19	Electric Force	637
19.1	Electric Charge	637
19.2	Charging Conductors and Insulators	639
19.3	Coulomb's Law	642
19.4	Exercises	651
20	Electric Fields	659
20.1	The Electric Field	659
20.2	The Electric Field of a Point Charge	660
20.3	The Electric Field of an Electric Dipole	666
20.4	Electric Field of a Continuous Charge Distribution	670
	20.4.1 The Electric Field Due to a Charged Rod	672
	20.4.2 The Electric Field of a Uniformly Charged Arc	679
	20.4.3 The Electric Field of a Uniformly Charged Ring	681
	20.4.4 The Electric Field of a Uniformly Charged Disk	682
20.5	Electric Field Lines	684

20.6	Motion of Charged Particles in a Uniform Electric Field	686
20.7	Exercises	691
21	Gauss's Law	701
21.1	Electric Flux	701
21.2	Gauss's Law	705
21.3	Applications of Gauss's Law	707
21.4	Conductors in Electrostatic Equilibrium.	717
21.5	Exercises	720
22	Electric Potential	731
22.1	Electric Potential Energy	731
22.2	Electric Potential	733
22.3	Electric Potential in a Uniform Electric Field.	735
22.4	Electric Potential Due to a Point Charge	741
22.5	Electric Potential Due to a Dipole	745
22.6	Electric Dipole in an External Electric Field	747
22.7	Electric Potential Due to a Charged Rod	749
22.8	Electric Potential Due to a Uniformly Charged Arc	752
22.9	Electric Potential Due to a Uniformly Charged Ring.	753
22.10	Electric Potential Due to a Uniformly Charged Disk.	754
22.11	Electric Potential Due to a Uniformly Charged Sphere	756
22.12	Electric Potential Due to a Charged Conductor	757
22.13	Potential Gradient	758
22.14	The Electrostatic Precipitator	761
22.15	The Van de Graaff Generator.	762
22.16	Exercises	763
23	Capacitors and Capacitance	773
23.1	Capacitor and Capacitance.	773
23.2	Calculating Capacitance.	775
23.3	Capacitors with Dielectrics	781
23.4	Capacitors in Parallel and Series.	790
23.5	Energy Stored in a Charged Capacitor.	795
23.6	Exercises	797
24	Electric Circuits	809
24.1	Electric Current and Electric Current Density.	809
24.2	Ohm's Law and Electric Resistance	814
24.3	Electric Power	823
24.4	Electromotive Force	825
24.5	Resistors in Series and Parallel.	829
24.6	Kirchhoff's Rules	834

24.7	The RC Circuit	838
24.8	Exercises	844

Part VI Magnetism

25	Magnetic Fields	859
25.1	Magnetic Force on a Moving Charge	859
25.2	Motion of a Charged Particle in a Uniform Magnetic Field . .	863
25.3	Charged Particles in an Electric and Magnetic Fields	865
25.3.1	Velocity Selector	866
25.3.2	The Mass Spectrometer	866
25.3.3	The Hall Effect	867
25.4	Magnetic Force on a Current-Carrying Conductor.	869
25.5	Torque on a Current Loop	874
25.5.1	Electric Motors.	876
25.5.2	Galvanometers	877
25.6	Non-Uniform Magnetic Fields	878
25.7	Exercises	879
26	Sources of Magnetic Field.	889
26.1	The Biot-Savart Law.	889
26.2	The Magnetic Force Between Two Parallel Currents.	895
26.3	Ampere's Law	897
26.4	Displacement Current and the Ampere-Maxwell Law	901
26.5	Gauss's Law for Magnetism.	903
26.6	The Origin of Magnetism	904
26.7	Magnetic Materials	908
26.8	Diamagnetism and Paramagnetism	910
26.9	Ferromagnetism	914
26.10	Some Applications of Magnetism	919
26.11	Exercises	921
27	Faraday's Law, Alternating Current, and Maxwell's Equations . .	933
27.1	Faraday's Law of Induction	933
27.2	Motional emf	936
27.3	Electric Generators	940
27.4	Alternating Current	942
27.5	Transformers	943
27.6	Induced Electric Fields	945
27.7	Maxwell's Equations of Electromagnetism	947
27.8	Exercises	950
28	Inductance, Oscillating Circuits, and AC Circuits	961
28.1	Self-Inductance.	961

28.2	Mutual Inductance	964
28.3	Energy Stored in an Inductor	966
28.4	The L - R Circuit	967
28.5	The Oscillating L - C Circuit	971
28.6	The L - R - C Circuit	974
28.7	Circuits with an ac Source	977
28.8	L - R - C Series in an ac Circuit	984
28.9	Resonance in L - R - C Series Circuit	988
28.10	Exercises	988
Appendix A Conversion Factors		999
Appendix B Basic Rules and Formulas		1003
Appendix C The Periodic Table of Elements		1013
Answers to All Exercises		1015
Index		1057