

Exploring Creation With Physics

Table of Contents

Introductory Remarks	1
The Metric System	2
The Factor-Label Method.....	2
Using Units in Mathematical Equations.....	3
Making Measurements	3
Accuracy, Precision, and Significant Figures	3
Scientific Notation.....	4
Mathematical Preparation	4
MODULE #1: Motion In One Dimension	5
Introduction	5
Distance and Displacement	6
Speed and Velocity.....	7
Average and Instantaneous Velocity	13
Experiment 1.1: Measuring Average Velocity.....	14
Velocity Is Relative	21
Acceleration	23
Experiment 1.2: Measuring an Object's Acceleration	24
Average And Instantaneous Acceleration	27
Answers to the "On Your Own" Problems	30
Review Questions.....	34
Practice Problems	35
MODULE #2: One-Dimensional Motion Equations and Free Fall	37
Introduction	37
Relating Velocity, Acceleration, and Time	37
Relating Velocity, Acceleration, and Displacement	39
Relating Displacement, Velocity, Acceleration, and Time.....	43
Using Our Equations For One-Dimensional Motion	47
Free Fall.....	50
Experiment 2.1: The Acceleration Due to Gravity Is the Same for All Objects.....	52
Experiment 2.2: Determining a Person's Reaction Time.....	54
A More Detailed Look At Free Fall	57
Terminal Velocity	60
Experiment 2.3: Factors That Affect Air Resistance	60
Answers to the "On Your Own" Problems	63
Review Questions.....	69
Practice Problems	70

MODULE #3: Two-Dimensional Vectors.....**71**

Introduction	71
Vectors	71
Adding and Subtracting Two-Dimensional Vectors: The Graphical Approach	74
Vector Components	78
Experiment 3.1: Vector Components	80
Determining A Vector's Components From Its Magnitude And Direction	85
Adding And Subtracting Two-Dimensional Vectors: The Analytical Approach	86
Applying Vector Addition To Physical Situations.....	90
Experiment 3.2: Vector Addition	90
Answers to the “On Your Own” Problems	96
Review Questions.....	102
Practice Problems	104

MODULE #4: Motion in Two Dimensions.....**105**

Introduction	105
Navigation in Two Dimensions.....	105
Projectile Motion in Two Dimensions	109
The Range Equation	115
Experiment 4.1: The Two Dimensions of a Rubber Band’s Flight.....	121
Two-Dimensional Situations In Which You Cannot Use The Range Equation	122
Experiment 4.2: Measuring the Horizontal Speed of an Object without a Stopwatch.....	124
Answers to the “On Your Own” Problems	128
Review Questions.....	138
Practice Problems	139

MODULE #5: Newton’s Laws.....**141**

Introduction	141
Sir Isaac Newton	141
Newton’s First Law	142
Experiment 5.1: Inertia.....	143
Newton’s Second Law.....	146
Mass And Weight.....	148
The Normal Force	152
Friction	155
Experiment 5.2: The Frictional Force	156
An Equation For The Frictional Force	160
Newton’s Third Law	166
Answers to the “On Your Own” Problems	168
Review Questions.....	174
Practice Problems	175

MODULE #6: Applications of Newton's Second Law 177

Introduction	177
Translational Equilibrium	177
Translational Equilibrium And Measuring Weight.....	185
Experiment 6.1: Measuring Acceleration in an Elevator	185
Rotational Motion And Torque	188
Experiment 6.2 What Causes Rotational Acceleration?	189
Rotational Equilibrium	193
Objects On An Inclined Surface.....	197
Experiment 6.3: Measuring a Coefficient of Static Friction	198
Applying Newton's Second Law To More Than One Object At A Time	202
Answers to the "On Your Own" Problems	206
Review Questions.....	214
Practice Problems	215

MODULE #7: Uniform Circular Motion and Gravity 217

Introduction	217
Uniform Circular Motion	217
Centripetal Force and Centripetal Acceleration	219
Experiment 7.1: Centripetal Force	219
The Source of Centripetal Force	223
A Fictional Force.....	228
Gravity	230
Circular Motion Terminology	235
Gravity and the Motion of Planets	237
Answers to the "On Your Own" Problems	243
Review Questions.....	248
Practice Problems	249

MODULE #8: Work and Energy 251

Introduction	251
The Definitions of Work and Energy	251
The Mathematical Definition of Work	252
Kinetic and Potential Energy.....	254
The First Law of Thermodynamics	258
Experiment 8.1: Energy in a Pendulum.....	265
Friction, Work, And Energy	267
Experiment 8.2: Estimating the Work Done by Friction	269
Energy And Power	274
Answers to the "On Your Own" Problems	277
Review Questions.....	284
Practice Problems	285

MODULE #9: Momentum 287

Introduction	287
Definition Of Momentum.....	287
Impulse	288
Experiment 9.1: Egg Drop.....	291
The Conservation Of Momentum.....	294
Experiment 9.2: Momentum and Energy Conservation.....	297
The Mathematics Of Momentum Conservation.....	300
Angular Momentum	305
Answers to the “On Your Own” Problems	310
Review Questions.....	315
Practice Problems	316

MODULE #10: Periodic Motion 317

Introduction	317
Hooke’s Law	317
Experiment 10.1: Hooke’s Law.....	317
Uniform Circular Motion: An Example Of Periodic Motion.....	324
The Mass / Spring System.....	325
Experiment 10.2: The Characteristics of a Mass / Spring System	325
The Mathematics Of The Mass / Spring System.....	328
More Analysis Of Experiment 10.2	331
Potential Energy In A Mass / Spring System	333
The Simple Pendulum	338
Answers to the “On Your Own” Problems	343
Review Questions.....	349
Practice Problems	350

MODULE #11: Waves..... 351

Introduction	351
Waves	351
The Physical Nature of Sound.....	354
Experiment 11.1: Frequency and Volume of Sound Waves	355
The Doppler Effect.....	359
Experiment 11.2: The Doppler Effect	360
Sound Waves in Substances Other Than Air	363
Sound Waves Beyond the Ear’s Ability to Hear	364
The Speed of Light	365
Light as a Wave	367
Light as a Particle	372
Biographies of Two Important Physicists	376
Answers to the “On Your Own” Problems	378
Review Questions.....	383
Practice Problems	384

MODULE #12: Geometric Optics 385

Introduction	385
The Law of Reflection.....	385
Experiment 12.1: The Law of Reflection.....	385
Flat Mirrors	387
Spherical Mirrors.....	388
Ray Tracing In Concave Spherical Mirrors	391
Experiment 12.2: Real and Virtual Images in a Concave Mirror.....	397
Ray Tracing In Convex Spherical Mirrors	398
Snell's Law Of Refraction.....	400
Experiment 12.3: Measuring the Index of Refraction of Glass.....	403
Converging Lenses.....	405
Diverging Lenses.....	408
The Human Eye.....	410
Answers to the "On Your Own" Problems	413
Review Questions.....	421
Practice Problems	422

MODULE #13: Coulomb's Law and the Electric Field 423

Introduction	423
The Basics of Electric Charge	423
Experiment 13.1: Attraction and Repulsion	424
Experiment 13.2: Making and Using an Electroscope	426
Electrostatic Force and Coulomb's Law	430
Multiple Charges and the Electrostatic Force	434
The Electric Field	439
Calculating the Strength of the Electric Field	443
Applying Coulomb's Law to the Bohr Model of the Atom	446
Answers to the "On Your Own" Problems	449
Review Questions.....	454
Practice Problems	455

MODULE #14: Electric Potential 457

Introduction	457
Electric Potential	457
Electric Potential, Potential Energy, and Potential Difference	459
Potential Difference and the Change in Potential Energy	460
Conservation of Energy in an Electric Potential	464
Capacitors	469
Experiment 14.1: Making a Parallel-Plate Capacitor and Storing Charge.....	470
An Application Of Capacitors.....	473
How A Television Makes Its Picture	476
Answers to the "On Your Own" Problems	478
Review Questions.....	485
Practice Problems	486

MODULE #15: Electric Circuits	487
Introduction	487
Batteries, Circuits, and Conventional Current	487
Resistance.....	491
Experiment 15.1: Current and Resistance	491
Electric Heaters	492
Electric Power	495
Switches And Circuits	497
Experiment 15.2: Building a Simple Circuit to Turn on a Light Bulb.....	497
Series And Parallel Circuits	500
Experiment 15.3: Series and Parallel Resistors.....	501
The Mathematics of Series and Parallel Circuits	504
Fuses and Circuit Breakers.....	508
Current and Power in Series and Parallel Circuits	510
Analyzing More Complicated Circuits	512
Answers to the “On Your Own” Problems	515
Review Questions.....	520
Practice Problems	521
MODULE #16: Magnetism.....	523
Introduction	523
Permanent Magnets	523
Magnetic Fields	525
How Magnets Become Magnetic	527
Experiment 16.1: Oersted’s Experiment	527
Experiment 16.2: Diamagnetic, Paramagnetic, and Ferromagnetic Compounds.....	530
The Earth’s Magnetic Field	532
The Magnetic Field of a Current-Carrying Wire	534
Faraday’s Law of Electromagnetic Induction	537
Using Faraday’s Law of Electromagnetic Induction.....	540
Alternating Current	541
Some Final Thoughts.....	543
Answers to the “On Your Own” Problems	544
Review Questions.....	545
Glossary	547
Appendix A	557
Appendix B	563
Appendix C	583
Index	589