

## **CONTENTS**

How to Use This Book   Xi	Preface		oage ix	1.7	Springs and Harmonic Oscillators	22	
1.7.3   Further Examples   25   1.7.4   Problems: Springs   27   27   27   28   28   29   29   29   29   29   29	How to Use This Book		xi				
Note	Resources		xii				
1.8   Fluid   Mechanics   1   1.8   Fluid   Mechanics   27						*	
The color of th	1					1 0	
1.1   Blocks on Ramps	<u>.</u>		-		1.8		
1.1   Block   1   1.8.2   Blocyant Forces   29	Classical Mechanics		/lechanics	1			
1.1.1       Blocks on Ramps       1       1.9       Solutions: Classical Mechanics       29         1.1.2       Falling and Hanging Blocks       2       2         1.1.3       Blocks in Contact       3       2         1.1.4       Problems: Blocks       3       2         1.2       Kinematics       5       Electricity and Magnetism       35         1.2.1       Circular Motion       5       Electricity and Magnetism       35         1.2.2       Problems: Kinematics       6       2.1       Electric Potential       35         1.3.1       Types of Energy       7       2.1.2       Electric Potential       35         1.3.1       Types of Energy       7       2.1.2       Electric Potential       35         1.3.3       Rolling Without Slipping       9       2.1.4       Standard Electrostatics Configurations       36         1.3.3       Rolling Without Slipping       9       2.1.4       Standard Electrostatics Configurations       36         1.3.3       Problems: Energy       11       2.1.5       Boundary Conditions       36         1.3.4       Work-Energy Theorem       11       2.1.6       Conductors       40         1.4.1       Linear Collisions<						,	
1.1.2       Falling and Hanging Blocks       2         1.1.3       Blocks in Contact       3         1.1.4       Problems: Blocks       3       2         1.2       Kinematics       5       Electricity and Magnetism       35         1.2.1       Circular Motion       5       Electricity and Magnetism       35         1.2.2       Problems: Kinematics       6       2.1       Electricity and Magnetism       35         1.3.2       Energy       7       2.1.1       Maxwell's Equations for Electrostatics       35         1.3.1       Types of Energy       7       2.1.2       Electric Potential       35         1.3.2       Kinetic/Potential Problems       8       2.1.3       Integral Form of Maxwell's Equations       36         1.3.3       Rolling Without Slipping       9       2.1.4       Standard Electrostatics Configurations       37         1.3.4       Work-Energy Theorem       11       2.1.5       Boundary Conditions       38         1.3.5       Problems: Energy       11       2.1.5       Mora and Energy in Electrostatics       40         1.4       Momentum       12       2.1.7       Method of Images       42         1.4.2       Rotational Motion and Angular M	1.1						
1.1.3 Blocks in Contact       3 cases       2         1.1.4 Problems: Blocks       3 days       2         1.2. Froblems: Blocks       5 days       5 description         1.2.1 Circular Motion       5 days       5 description         1.2.2 Problems: Kinematics       6 days       2.1 electricatatics       35         1.3.1 Types of Energy       7 days ell: electric Potential       35         1.3.2 Kinetic/Potential Problems       8 days       2.1.3 lategral Form of Maxwell's Equations       36         1.3.3 Rolling Without Slipping       9 days       2.1.4 standard Electrostatics Configurations       36         1.3.4 Work-Energy Theorem       11 days       2.1.5 Boundary Conditions       38         1.3.4 Work-Energy Theorem       11 days       2.1.6 Conductors       40         1.4 Moment under Collisions       12 days       2.1.7 Method of Images       40         1.4 Scational Motion and Angular Momentum       12 days       2.1.8 Work and Energy in Electrostatics       42         1.4.1 Linear Collisions       12 days       2.1.9 Capacitors       43         1.4.2 Rotational Motion and Angular Momentum       12 days       2.1.1 Problems: Electrostatics       45         1.4.2 Rotational Motion and Energian Motion and Electrostatics       45       45			-		1.9	Solutions: Classical Mechanics	29
1.1.4 Problems: Blocks       3       2         1.2 Kinesster       5       Electricity       To Gircular Motion       35         1.2.1 Circular Motion       5       Electricity       Magnetism       35         1.2.2 Problems: Kinematics       6       2.1 Electricity       35         1.3 Energy       7       2.1.1 Maxwell's Equations for Electrostatics       35         1.3.1 Types of Energy       7       2.1.2 Electric Potential       35         1.3.2 Kinetic/Potential Problems       8       2.1.3 Integral Form of Maxwell's Equations       36         1.3.3 Rolling Without Slipping       9       2.1.4 Standard Electrostatics Configurations       37         1.3.4 Work-Energy Theorem       11       2.1.5 Boundary Conditions       38         1.3.5 Problems: Energy       11       2.1.6 Conductors       40         1.4 Initial Linear Collisions       12       2.1.7 Method of Images       40         1.4.1 Linear Collisions       12       2.1.8 Work and Energy in Electrostatics       42         1.4.2 Rotational Motion and Angular Momentum       12       2.1.9 Capacitors       43         1.4.3 Moment of Inertia       14       2.1.9 Capacitors       45         1.4.4 Center of Mass       15       2.2 Magnetostatics							
1.2   Kins					2		
1.2.1 Gircular Motion       5       Electricity and Magnetism       35         1.2.2 Problems: Kinematics       6       2.1 Electricatics       35         1.3 Energy       7       2.1.1 Maxwell's Equations for Electrostatics       35         1.3.1 Types of Energy       7       2.1.2 Electric Potential       35         1.3.2 Kinetic/Potential Problems       8       2.1.3 Integral Forn of Maxwell's Equations       36         1.3.3 Rolling Without Slipping       9       2.1.4 Standard Electrostatics Configurations       36         1.3.4 Work-Energy Theorem       11       2.1.5 Boundary Conditions       38         1.3.5 Problems: Energy       11       2.1.6 Conductors       40         1.4 Iniar Collisions       12       2.1.7 Method of Images       40         1.4.1 Linear Collisions       12       2.1.8 Work and Energy in Electrostatics       42         1.4.2 Rotational Motion and Angular Momentum       12       2.1.8 Work and Energy in Electrostatics       43         1.4.2 Problems: Momentum       15       2.2 Magnetistatics       45         1.5.1 Lagrangians and Hamiltonians       16       2.2.1 Basic Tools       45         1.5.1 Lagrangians       16       2.2.2 Mapère's Law and the Biot-Savart Law       46         1.5.1 Egrangian	4.5						
1.2.2       Problems: Kinematics       6       2.1       Electratics       35         1.3       Energy       7       2.1.1       Maxwell's Equations for Electrostatics       35         1.3.1       Types of Energy       7       2.1.2       Electric Potential       35         1.3.2       Kinetic/Potential Problems       8       2.1.3       Integral Form of Maxwell's Equations       36         1.3.3       Rolling Without Slipping       9       2.1.4       Standard Electrostatics Configurations       37         1.3.4       Work—Energy Theorem       11       2.1.5       Boundary Conditions       38         1.3.5       Problems: Energy       11       2.1.6       Conductors       40         1.4       Morrest Energy       11       2.1.6       Conductors       40         1.4.1       Linear Collisions       12       2.1.7       Method of Images       40         1.4.2       Rotational Motion and Angular Momentum       12       2.1.8       Work and Energy in Electrostatics       42         1.4.2       Rotational Motion and Angular Momentum       12       2.1.0       Problems: Electrostatics       45         1.4.2       Problems: Momentum       15       2.2       Magnetiotsatics       <	1.2				Eloc	tricity and Magnatism	25
2.1. Belectivations         35           1.3.1 Types of Energy         7         2.1.2 Electric Potential         35           1.3.2 Kinetic/Potential Problems         8         2.1.3 Integral Form of Maxwell's Equations         36           1.3.3 Rolling Without Slipping         9         2.1.4 Standard Electrostatics Configurations         37           1.3.4 Work-Energy Theorem         11         2.1.5 Boundary Conditions         38           1.3.5 Problems: Energy         11         2.1.6 Conductors         40           1.4.1 Linear Collisions         12         2.1.7 Method of Images         40           1.4.2 Rotational Motion and Angular Momentum         12         2.1.8 Work and Energy in Electrostatics         42           1.4.2 Rotational Motion and Angular Momentum         12         2.1.9 Problems: Electrostatics         43           1.4.3 Moment of Inertia         14         2.1.10 Problems: Electrostatics         45           1.4.4 Center of Mass         15         2.2 Magnetostatics         45           1.4.5 Problems: Momentum         16         2.2.1 Basic Tools         45           1.5.1 Lagrangians and Hamiltonians         16         2.2.2 Ampère's Law and the Biot–Savart Law         46           1.5.1 Lagrangians and Hamilton's Equations         2.2.4 Boundary Conditions         48						cricity and magnetism	35
1.3.1       Types of Energy       7       2.1.2       Electric Potential       35         1.3.2       Kinetic/Potential Problems       8       2.1.3       Integral Form of Maxwell's Equations       36         1.3.3       Rolling Without Slipping       9       2.1.4       Standard Electrostatics Configurations       37         1.3.4       Work-Energy Theorem       11       2.1.5       Boundary Conditions       38         1.3.5       Problems: Energy       11       2.1.6       Conductors       40         1.4       Momentum       12       2.1.7       Method of Images       40         1.4.1       Linear Collisions       12       2.1.8       Work and Energy in Electrostatics       42         1.4.2       Rotational Motion and Angular Momentum       12       2.1.9       Capacitors       43         1.4.3       Moment of Inertia       14       2.1.10       Problems: Electrostatics       44         1.4.4       Center of Mass       15       2.2       Magnetostatics       45         1.4.5       Problems: Momentum       15       2.2.1       Basic Tools       45         1.5.1       Lagrangians       16       2.2.2       Ampère's Law and the Biot–Savart Law       46					2.1	Electrostatics	35
1.3.2       Kinetic/Potential Problems       8       2.1.3       Integral Form of Maxwell's Equations       36         1.3.3       Rolling Without Slipping       9       2.1.4       Standard Electrostatics Configurations       37         1.3.4       Work-Energy Theorem       11       2.1.5       Boundary Conditions       38         1.3.5       Problems: Energy       11       2.1.6       Conductors       40         1.4       Momentum       12       2.1.7       Method of Images       40         1.4.1       Linear Collisions       12       2.1.8       Work and Energy in Electrostatics       42         1.4.2       Rotational Motion and Angular Momentum       12       2.1.9       Capacitors       43         1.4.3       Moment of Inertia       14       2.1.10       Problems: Electrostatics       44         1.4.4       Center of Mass       15       2.2       Magnetostatics       45         1.4.5       Problems: Momentum       15       2.2.1       Basic Tools       45         1.5.1       Lagrangians and Hamiltonians       16       2.2.2       Ampère's Law and the Biot–Savart Law       46         1.5.2       Euler–Lagrange Equations       17       2.2.4       Boundary Conditions	1.3					<b>2.1.1</b> Maxwell's Equations for Electrostatics	35
1.3.3       Rolling Without Slipping       9       2.1.4       Standard Electrostatics Configurations       37         1.3.4       Work-Energy Theorem       11       2.1.5       Boundary Conditions       38         1.3.5       Problems: Energy       11       2.1.6       Conductors       40         1.4       Moment Collisions       12       2.1.7       Method of Images       40         1.4.1       Linear Collisions       12       2.1.8       Work and Energy in Electrostatics       42         1.4.2       Rotational Motion and Angular Momentum       12       2.1.9       Capacitors       43         1.4.3       Moment of Inertia       14       2.1.10       Problems: Electrostatics       44         1.4.4       Center of Mass       15       2.2       Magnetostatics       45         1.4.5       Problems: Momentum       15       2.2.1       Basic Tools       45         1.5.1       Lagrangians and Hamiltonians       16       2.2.2       Ampère's Law and the Biot-Savart Law       46         1.5.1       Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.2       Euler-Lagrange Equations       17       2.2.4       Boundary Conditions       48						2.1.2 Electric Potential	35
1.3.4       Work-Energy Theorem       11       2.1.5       Boundary Conditions       38         1.3.5       Problems: Energy       11       2.1.6       Conductors       40         1.4       Momentum       12       2.1.7       Method of Images       40         1.4.1       Linear Collisions       12       2.1.8       Work and Energy in Electrostatics       42         1.4.2       Rotational Motion and Angular Momentum       12       2.1.9       Capacitors       43         1.4.3       Moment of Inertia       14       2.1.10       Problems: Electrostatics       44         1.4.4       Center of Mass       15       2.2       Magnetostatics       45         1.4.5       Problems: Momentum       15       2.2.1       Basic Tools       45         1.5.1       Lagrangians and Hamiltonians       16       2.2.2       Ampèrès Law and the Biot-Savart Law       46         1.5.1       Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.2       Euler-Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.2       Hamiltonians and Hamiltonians       18       2.2.6       Cyclotron Motion       48         <							
1.3.5 Problems: Energy       11       2.1.6 Conductors       40         1.4 Mom—tum       12       2.1.7 Method of Images       40         1.4.1 Linear Collisions       12       2.1.8 Work and Energy in Electrostatics       42         1.4.2 Rotational Motion and Angular Momentum       12       2.1.9 Capacitors       43         1.4.3 Moment of Inertia       14       2.1.10 Problems: Electrostatics       44         1.4.4 Center of Mass       15       2.2 Magn—tstatics       45         1.4.5 Problems: Momentum       15       2.2.1 Basic Tools       45         1.5 Lagrangians and Hamiltonians       16       2.2.2 Ampère's Law and the Biot–Savart Law       46         1.5.1 Lagrangians       16       2.2.3 Standard Magnetostatics Configurations       46         1.5.2 Euler–Lagrange Equations       17       2.2.4 Boundary Conditions       48         1.5.3 Hamiltonians and Hamilton's Equations       2.2.5 Work and Energy in Magnetostatics       48         1.5.4 Problems: Lagrangians and Hamiltonians       19       2.2.5 Problems: Magnetostatics       49         1.6 Orbits       19       2.3 Electrodynamics       49         1.6.1 Effective Potential       19       2.3.1 Maxwell's Equations       49         1.6.2 Classification of Orbits       20 <td></td> <td></td> <td></td> <td></td> <td></td> <td><b>2.1.4</b> Standard Electrostatics Configurations</td> <td>37</td>						<b>2.1.4</b> Standard Electrostatics Configurations	37
1.4       Momentum       12       2.1.7       Method of Images       40         1.4.1       Linear Collisions       12       2.1.8       Work and Energy in Electrostatics       42         1.4.2       Rotational Motion and Angular Momentum       12       2.1.9       Capacitors       43         1.4.3       Moment of Inertia       14       2.1.10       Problems: Electrostatics       44         1.4.4       Center of Mass       15       2.2       Magnetostatics       45         1.4.5       Problems: Momentum       15       2.2.1       Basic Tools       45         1.5.1       Lagrangians and Hamiltonians       16       2.2.2       Ampère's Law and the Biot-Savart Law       46         1.5.1       Lagrangians       16       2.2.2       Ampère's Law and the Biot-Savart Law       46         1.5.2       Euler-Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.3       Hamiltonians and Hamiltonians       18       2.2.5       Work and Energy in Magnetostatics       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.2.7       Problems: Magnetostatics       49         1.6.1       Effective Potential       19       2.3.1       Maxwe			<del>-</del> ·			<b>2.1.5</b> Boundary Conditions	38
1.4.1       Linear Collisions       12       2.1.8       Work and Energy in Electrostatics       42         1.4.2       Rotational Motion and Angular Momentum       12       2.1.9       Capacitors       43         1.4.3       Moment of Inertia       14       2.1.10       Problems: Electrostatics       44         1.4.4       Center of Mass       15       2.2       Magn=tostatics       45         1.4.5       Problems: Momentum       15       2.2.1       Basic Tools       45         1.5       Lagrangians and Hamiltonians       16       2.2.2       Ampère's Law and the Biot–Savart Law       46         1.5.1       Lagrangians       16       2.2.3       Standard Magnetostatics Configurations       46         1.5.2       Euler-Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.3       Hamiltonians and Hamilton's Equations       18       2.2.5       Work and Energy in Magnetostatics Configurations       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.2.5       Work and Energy in Magnetostatics Configurations       48         1.6.1       Effective Potential       19       2.3       Electrodynamics       49         1.6.2       Classification of Orbi		1.3.5	Problems: Energy	11			40
1.4.2       Rotational Motion and Angular Momentum       12       2.1.9       Capacitors       43         1.4.3       Moment of Inertia       14       2.1.10       Problems: Electrostatics       44         1.4.4       Center of Mass       15       2.2       Magn=tostatics       45         1.4.5       Problems: Momentum       15       2.2.1       Basic Tools       45         1.5       Lagrangians and Hamiltonians       16       2.2.2       Ampère's Law and the Biot–Savart Law       46         1.5.1       Lagrangians       16       2.2.3       Standard Magnetostatics Configurations       46         1.5.2       Euler–Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.3       Hamiltonians and Hamilton's Equations       2.2.5       Work and Energy in Magnetostatics       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.2.6       Cyclotron Motion       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.3       Electrodynamics       49         1.6.1       Effective Potential       19       2.3       Electrodynamics       49         1.6.2       Classification of Orbits       20       2.3.2       Faraday	1.4	Momentum				<b>2.1.7</b> Method of Images	40
1.4.3       Moment of Inertia       14       2.1.10       Problems: Electrostatics       44         1.4.4       Center of Mass       15       2.2       Magn=tostatics       45         1.4.5       Problems: Momentum       15       2.2.1       Basic Tools       45         1.5       Lagrangians and Hamiltonians       16       2.2.2       Ampère's Law and the Biot-Savart Law       46         1.5.1       Lagrangians       16       2.2.3       Standard Magnetostatics Configurations       46         1.5.2       Euler-Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.3       Hamiltonians and Hamilton's Equations       2.2.5       Work and Energy in Magnetostatics       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.2.7       Problems: Magnetostatics       49         1.6       Orbits       19       2.3       Electrodynamics       49         1.6.1       Effective Potential       19       2.3.1       Maxwell's Equations       49         1.6.2       Classification of Orbits       20       2.3.2       Faraday's Law       50         1.6.3       Kepler's "Laws"       21       2.3.3       Inductors       50 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td><b>2.1.8</b> Work and Energy in Electrostatics</td> <td>42</td>						<b>2.1.8</b> Work and Energy in Electrostatics	42
1.4.4       Center of Mass       15       2.2       Magn=tostatics       45         1.4.5       Problems: Momentum       15       2.2.1       Basic Tools       45         1.5       Lagrangians and Hamiltonians       16       2.2.2       Ampère's Law and the Biot–Savart Law       46         1.5.1       Lagrangians       16       2.2.3       Standard Magnetostatics Configurations       46         1.5.2       Euler-Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.3       Hamiltonians and Hamilton's Equations       2.2.5       Work and Energy in Magnetostatics       48         of Motion       18       2.2.6       Cyclotron Motion       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.2.7       Problems: Magnetostatics       49         1.6       Orbits       19       2.3       Electrodynamics       49         1.6.1       Effective Potential       19       2.3.1       Maxwell's Equations       49         1.6.2       Classification of Orbits       20       2.3.2       Faraday's Law       50         1.6.3       Kepler's "Laws"       21       2.3.3       Inductors       50			Rotational Motion and Angular Momentum	12		1	43
1.4.5       Problems: Momentum       15       2.2.1       Basic Tools       45         1.5       Lagrangians and Hamiltonians       16       2.2.2       Ampère's Law and the Biot-Savart Law       46         1.5.1       Lagrangians       16       2.2.3       Standard Magnetostatics Configurations       46         1.5.2       Euler-Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.3       Hamiltonians and Hamilton's Equations       2.2.5       Work and Energy in Magnetostatics       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.2.6       Cyclotron Motion       48         1.6.1       Effective Potential       19       2.3       Electrodynamics       49         1.6.2       Classification of Orbits       20       2.3.1       Maxwell's Equations       49         1.6.3       Kepler's "Laws"       21       2.3.3       Inductors       50		1.4.3	Moment of Inertia			<b>2.1.10</b> Problems: Electrostatics	44
1.5       Lagrangians and Hamiltonians       16       2.2.2       Ampère's Law and the Biot-Savart Law       46         1.5.1       Lagrangians       16       2.2.3       Standard Magnetostatics Configurations       46         1.5.2       Euler-Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.3       Hamiltonians and Hamilton's Equations of Motion       18       2.2.5       Work and Energy in Magnetostatics       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.2.7       Problems: Magnetostatics       49         1.6       Orbits of Drbits of Classification of Orbits       19       2.3       Electrodynamics       49         1.6.2       Classification of Orbits of Orbits of Classification of		<b>1.4.4</b> Center of Mass			2.2	Magnetostatics	45
1.5.1       Lagrangians       16       2.2.3       Standard Magnetostatics Configurations       46         1.5.2       Euler-Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.3       Hamiltonians and Hamilton's Equations of Motion       18       2.2.5       Work and Energy in Magnetostatics       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.2.7       Problems: Magnetostatics       49         1.6       Orbits       19       2.3       Electrodynamics       49         1.6.1       Effective Potential       19       2.3.1       Maxwell's Equations       49         1.6.2       Classification of Orbits       20       2.3.2       Faraday's Law       50         1.6.3       Kepler's "Laws"       21       2.3.3       Inductors       50		1.4.5	Problems: Momentum	15		<b>2.2.1</b> Basic Tools	45
1.5.2       Euler-Lagrange Equations       17       2.2.4       Boundary Conditions       48         1.5.3       Hamiltonians and Hamilton's Equations       2.2.5       Work and Energy in Magnetostatics       48         of Motion       18       2.2.6       Cyclotron Motion       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.2.7       Problems: Magnetostatics       49         1.6       Orbits       19       2.3       Electrodynamics       49         1.6.1       Effective Potential       19       2.3.1       Maxwell's Equations       49         1.6.2       Classification of Orbits       20       2.3.2       Faraday's Law       50         1.6.3       Kepler's "Laws"       21       2.3.3       Inductors       50	1.5	Lagrangians and Hamiltonians		16		2.2.2 Ampère's Law and the Biot-Savart Law	46
1.5.3 Hamiltonians and Hamilton's Equations of Motion 18 2.2.6 Cyclotron Motion 48 1.5.4 Problems: Lagrangians and Hamiltonians 19 2.2.7 Problems: Magnetostatics 49 1.6 Orbits 19 2.3 Electrodynamics 49 1.6.1 Effective Potential 19 2.3.1 Maxwell's Equations 49 1.6.2 Classification of Orbits 20 2.3.2 Faraday's Law 50 1.6.3 Kepler's "Laws" 21 2.3.3 Inductors 50		1.5.1	Lagrangians	16		2.2.3 Standard Magnetostatics Configurations	46
of Motion       18       2.2.6       Cyclotron Motion       48         1.5.4       Problems: Lagrangians and Hamiltonians       19       2.2.7       Problems: Magnetostatics       49         1.6       Orbits       19       2.3       Electrodynamics       49         1.6.1       Effective Potential       19       2.3.1       Maxwell's Equations       49         1.6.2       Classification of Orbits       20       2.3.2       Faraday's Law       50         1.6.3       Kepler's "Laws"       21       2.3.3       Inductors       50		1.5.2	Euler–Lagrange Equations	17		<b>2.2.4</b> Boundary Conditions	48
1.5.4Problems: Lagrangians and Hamiltonians192.2.7Problems: Magnetostatics491.6Orbits192.3Electrodynamics491.6.1Effective Potential192.3.1Maxwell's Equations491.6.2Classification of Orbits202.3.2Faraday's Law501.6.3Kepler's "Laws"212.3.3Inductors50		1.5.3	Hamiltonians and Hamilton's Equations			<b>2.2.5</b> Work and Energy in Magnetostatics	48
1.6       Orbits       19       2.3       Electrodynamics       49         1.6.1       Effective Potential       19       2.3.1       Maxwell's Equations       49         1.6.2       Classification of Orbits       20       2.3.2       Faraday's Law       50         1.6.3       Kepler's "Laws"       21       2.3.3       Inductors       50			of Motion	18		<b>2.2.6</b> Cyclotron Motion	48
1.6.1 Effective Potential       19       2.3.1 Maxwell's Equations       49         1.6.2 Classification of Orbits       20       2.3.2 Faraday's Law       50         1.6.3 Kepler's "Laws"       21       2.3.3 Inductors       50		1.5.4	Problems: Lagrangians and Hamiltonians	19		<b>2.2.7</b> Problems: Magnetostatics	49
1.6.2 Classification of Orbits       20       2.3.2 Faraday's Law       50         1.6.3 Kepler's "Laws"       21       2.3.3 Inductors       50	1.6	Orbits		19	2.3	Electrodynamics	49
1.6.2 Classification of Orbits       20       2.3.2 Faraday's Law       50         1.6.3 Kepler's "Laws"       21       2.3.3 Inductors       50		<b>1.6.1</b> Effective Potential		19		•	49
<b>1.6.3</b> Kepler's "Laws" 21 <b>2.3.3</b> Inductors 50		1.6.2	Classification of Orbits	20			50
<b>1.6.4</b> Problems: Orbits 22 <b>2.3.4</b> Problems: Electrodynamics 51		1.6.3	Kepler's "Laws"	21			50
		1.6.4	Problems: Orbits	22		<b>2.3.4</b> Problems: Electrodynamics	51

2.4	Dipoles	52		<b>4.1.3</b> Classical Limit	80
	<b>2.4.1</b> Electric Dipoles	52		<b>4.1.4</b> Equipartition Theorem	80
	<b>2.4.2</b> Magnetic Dipoles	52		<b>4.1.5</b> Some Combinatorial Facts	80
	2.4.3 Multipole Expansion	53	4.2	Thermodynamics	80
	<b>2.4.4</b> Problems: Dipoles	53		<b>4.2.1</b> Three Laws	81
2.5	Matter Effects	53		<b>4.2.2</b> Gases and Equations of State	82
	<b>2.5.1</b> Polarization	54		<b>4.2.3</b> Types of Processes	82
	2.5.2 Dielectrics	54		<b>4.2.4</b> Relations Between Thermodynamic Variables	84
	<b>2.5.3</b> Problems: Matter Effects	54 54		<b>4.2.5</b> Heat Capacity	84
2.6	Electromagnetic Waves			<b>4.2.6</b> Model Systems	85
	<b>2.6.1</b> Wave Equation and Poynting Vector	54	4.3	Quantum Statistical Mechanics	87
	2.6.2 Radiation	56	4.4	Problems: Thermodynamics and Statistical	
	<b>2.6.3</b> Problems: Electromagnetic Waves	56 56		Mechanics	88
2.7	Circuits		4.5	Solutions: Thermodynamics and Statistical	
	2.7.1 Basic Elements			Mechanics	90
	2.7.2 Kirchhoff's Rules	57			
	2.7.3 Energy in Circuits	57 50	5		
	<ul><li>2.7.4 Standard Circuit Types</li><li>2.7.5 Problems: Circuits</li></ul>	58 58	0.112	ntum Machanics and Atomic Physics	0.2
20			-	ntum Mechanics and Atomic Physics	92
2.8	Solutions: Electricity and Magnetism	59	5.1	Formalism (How To Calculate)	92
_				<b>5.1.1</b> Wavefunctions and Operators	92
3				<b>5.1.2</b> Dirac Notation	94
				<b>5.1.3</b> Schrödinger Equation	95
Optics and Waves		63		<ul><li>5.1.4 Commutators and the Uncertainty Principle</li><li>5.1.5 Problems: Formalism</li></ul>	96 98
3.1	Properties of Waves	63	5.2	Harmonic Oscillator	99
	<b>3.1.1</b> Wave Equation	63	3.2	<b>5.2.1</b> One Dimension	99
	<b>3.1.2</b> Nomenclature and Complex Notation	63			100
	3.1.3 Dispersion Relations	65			101
	3.1.4 Examples of Waves	65 65	5.3		101
	<ul><li>3.1.5 Index of Refraction</li><li>3.1.6 Polarization</li></ul>	66	٥.5		101
2.2				•	102
3.2	Interference and Diffraction	67			102
	3.2.1 Double-Slit Interference	67			103
	<ul><li>3.2.2 Single-Slit Diffraction</li><li>3.2.3 Optical Path Length</li></ul>	68 69		<b>5.3.5</b> Scattering States: Reflection and Transmission	
	<ul><li>3.2.3 Optical Path Length</li><li>3.2.4 Thin Films and Phase Shifts</li></ul>	68 69			104
	3.2.5 Miscellaneous Diffraction	70	5.4		104
3.3		70		-	105
3.3	Geometric Optics  3.3.1 Reflection and Refraction	70 70		<b>5.4.2</b> Angular Momentum and Spherical Harmonics	
	3.3.2 Lenses and Mirrors	70			106
3.4		72		<b>5.4.4</b> Problems: Quantum Mechanics in Three	
3.4	Assorted Extra Topics 3.4.1 Rayleigh Scattering	72 72		Dimensions	108
	3.4.2 Doppler Effect	72	5.5	Spin	108
	3.4.3 Standing Sound Waves	73		1	108
3.5	Problems: Optics and Waves	74		<b>5.5.2</b> Spin and the Wavefunction	109
	•			<b>5.5.3</b> Adding Spins	110
3.6	Solutions: Optics and Waves	75			111
4				<b>5.5.5</b> Problems: Spin	112
4			5.6	Approximation Methods	113
Thor	modynamics and Statistical Mechanics	<b>s</b> 78		<b>5.6.1</b> Time-Independent Perturbation Theory:	
	•				113
4.1	Basic Statistical Mechanics	78		1	114
	<b>4.1.1</b> Ensembles and the Partition Function	78			114
	<b>4.1.2</b> Entropy	79		<b>5.6.4</b> Problems: Approximation Methods	114

5.7	Atomic Physics Topics	115	7.6	Problems: Laboratory Methods	143
	<b>5.7.1</b> Bohr Model	115	7.7	Solutions: Laboratory Methods	145
	<b>5.7.2</b> Perturbations to Hydrogen Atoms	115		,	
	<b>5.7.3</b> Shell Model and Electronic Notation	116	_		
	<b>5.7.4</b> Stark and Zeeman Effects	116	8		
	5.7.5 Selection Rules	117	Snec	ialized Topics	146
	5.7.6 Blackbody Radiation	117	-	•	
г о	5.7.7 Problems: Atomic Physics Topics	118	8.1	Nuclear and Particle Physics	146
5.8	Solutions: Quantum Mechanics and Atomic			8.1.1 The Standard Model: Particles and	146
	Physics	119		Interactions 8.1.2 Nuclear Physics: Bound States	146 147
6				8.1.3 Symmetries and Conservation Laws	148
				8.1.4 Recent Developments	149
Special Relativity			8.2	Condensed Matter Physics	149
6.1	Relativity Basics	123		<b>8.2.1</b> Crystal Structure	149
	<b>6.1.1</b> Simultaneity	124		<b>8.2.2</b> Electron Theory of Metals	150
	<b>6.1.2</b> Time Dilation	124		<b>8.2.3</b> Semiconductors	151
	<b>6.1.3</b> Lorentz Contraction	124		<b>8.2.4</b> Superconductors	151
	<b>6.1.4</b> Velocity Addition	125	8.3	Astrophysics	152
6.2	4-Vectors	125	8.4	Recent Nobel Prizes	153
	<b>6.2.1</b> Lorentz Transformation Matrices	125	8.5	Problems: Specialized Topics	155
	<b>6.2.2</b> Relativistic Dot Product	126	8.6	Solutions: Specialized Topics	157
6.3	Relativistic Kinematics	127			
	6.3.1 Conserved vs. Invariant	127			
<i>.</i> .	<b>6.3.2</b> Exploiting the Invariant Dot Product	128	9		
6.4	Miscellaneous Relativity Topics	129			
	<ul><li>6.4.1 Relativistic Doppler Shift</li><li>6.4.2 Pythagorean Triples</li></ul>	129 129	Spec	ial Tips and Tricks for the Physics GRE	159
6.5	Relativity: What to Memorize	129	9.1	Derive, Don't Memorize	159
6.6	•		9.2	Dimensional Analysis	160
	Problems: Special Relativity	130	9.3	Limiting Cases	161
6.7	Solutions: Special Relativity	131	9.4	Numbers and Estimation	162
_			9.5	Answer Types (What to Remember in a Formula)	
7			9.6	General Test-Taking Strategies	165
Laboratory Methods			9.7	Problems: Tips and Tricks	165
		134	9.8	Solutions: Tips and Tricks	166
7.1	Graph Reading	134	9.6	Solutions: Tips and Tricks	100
	<ul><li>7.1.1 Dimensional Analysis</li><li>7.1.2 Log Plots</li></ul>	134 134	_		
7.2	Statistics	135	Sam	ple Exams and Solutions	167
1.2	7.2.1 Error Analysis	135	Samp	le Exam 1	169
	7.2.1 Error Analysis 7.2.2 Poisson Processes	136	_	le Exam 2	187
7.3	Electronics	136	_	le Exam 3	209
7.5	<b>7.3.1</b> AC Behavior of Basic Circuit Elements		Answers to Sample Exam 1		227
	<b>7.3.2</b> More Advanced Circuit Elements	136 138		ers to Sample Exam 2	228
	<b>7.3.3</b> Logic Gates	138		ers to Sample Exam 3	229
7.4	Radiation Detection and Instrumentation		Solutions to Sample Exam 1		
	<b>7.4.1</b> Interaction of Charged Particles with Matter	139 139		-	230
	<b>7.4.2</b> Photon Interactions	140	Solutions to Sample Exam 2		243
	<b>7.4.3</b> General Properties of Particle Detectors	141	Solut	ions to Sample Exam 3	254
	<b>7.4.4</b> Radioactive Decays	141			
7.5	Lasers and Interferometers		Refere		267
	<b>7.5.1</b> Generic Laser Operation	141	•	ion Index	268
	<b>7.5.2</b> Types of Lasers	142	Subje	ct Index	276
	<b>7.5.3</b> Interferometers	143	Proble	ems Index	280