Contents

26	CHARGE AND MATTER	555
	26-1 Electromagnetism-A Preview 555	
	26-2 Electric Charge 556	
	26-3 Conductors and Insulators 557	
	26-4 Coulomb's Law 558	
	26-5 Charge Is Quantized 562	
	26-6 Charge and Matter 563	
	26-7 Charge Is Conserved 568	
27 -	THE ELECTRIC FIELD	571
21		371
	27-1 The Electric Field 571	
	27-2 The Electric Field Strength E 573	
	27-3 Lines of Force 573	
	27-4 Calculation of E 578	
	27-5 A Point Charge in an Electric Field 583	
	27-6 A Dipole in an Electric Field 586	
28	GAUSS'S LAW	594
	28-1 Flux of the Electric Field 594	
	28-2 Gauss's Law 598	
	28-3 Gauss's Law and Coulomb's Law 598	
	28-4 An Insulated Conductor 600	
	28-5 Experimental Proof of Gauss's and Coulomb's Laws 601	
	28-6 Gauss's Law-Some Applications 603	
	28-7 The Nuclear Model of the Atom 608	
	xl	

xii **contents**

29	ELECTRIC POTENTIAL	616
	29-1 Electric Potential 616	
	29-2 Potential and Field Strength 619	
	29-3 Potential Due to a Point Charge 623	
	29-4 A Group of Point Charges 624	
	29-5 Potential Due to a Dipole 626	
	29-6 Electric Potential Energy 630	
	29-7 Calculation of E from V 632	
	29-8 An Insulated Conductor 638	
	29-9 The Electrostatic Generator 641	
30	CAPACITORS AND DIELECTRICS	649
	30-1 Capacitance 649	
	30-2 Calculating Capacitance 653	
	30-3 Parallel-Plate Capacitor with Dielectric 656	
	30-4 Dielectrics-An Atomic View 658	
	30-5 Dielectrics and Gauss's Law 661	
	30-6 Three Electric Vectors 664	
	30-7 Energy Storage in an Electric Field 668	
31	CURRENT AND RESISTANCE	678
	31-1 Current and Current Density 678	
	31-2 Resistance, Resistivity, and Conductivity 682	
	31-3 Ohm's Law 686	
	31-4 Resistivity-An Atomic View 688	
	31-5 Energy Transfers in an Electric Circuit 691	
32	ELECTROMOTIVE FORCE AND CIRCUITS	697
	32-1 Electromotive Force 697	
	32-2 Calculating the Current 700	
	32-3 Other Single-Loop Circuits 701	
	32-4 Potential Differences 703	
	32-5 Multiloop Circuits 706	
	32-6 Measuring Currents and Potential Differences 708	
	32-7 The Potentiometer 709	
	32-8 RC Circuits 710	
33	THE MAGNETIC FIELD	722
	33-1 The Magnetic Field 722	
	33-2 The Definition of B 724	
	33-3 Magnetic Force on a Current 727	
	33-4 Torque on a Current Loop 731	
	33-5 The Hall Effect 735	
	33-6 Circulating Charges 737	
	33-7 The Cyclotron 739	
	33-8 Thomson's Experiment 743	

	CONTENTS	xiii
34	AMAPERE'S LAW	752
	34-1 Amp&e's Law 752	
	34-2 B Near a Long Wire 756	
	34-3 Magnetic Lines of Induction 759	
	34-4 Two Parallel Conductors 761	
	34- 5 B for a Solenoid 764	
	{34-6 The Biot-Savart Law 767	
35	FARADAY'S LAW	778
	35-1 Faraday's Experiments 778	
	35-2 Faraday's Law of Induction 780	
	35-3 Lena's Law 781	
	35-4 Induction-A Quantitative Study 783	
	35-4 Induction-A Quantitative Study 783	
	35-6 The Betatron 792	
	35-7 Induction and Relative Motion 796	
	33-7 Induction and Relative Motion 790	
36	INDUCTANCE	807
-	36-1 Inductance 807	007
	36-2 Calculation of Inductance 809	
	36-3 An LR Circuit 810	
	36-4 Energy and the Magnetic Field 815	
	36-5 Energy Density and the Magnetic Field 818	
37	MAGNETIC PROPERTIES OF MATTER	823
	37-1 Poles and Dipoles 823 37-2 Gauss's Law for Magnetism 828	
	37-3 Paramagnetism 828 37-4 Diamagnetism 831	
	37-5 Ferromagnetism 834	
	37-6 Nuclear Magnetism 839	
	37-7 Three Magnetic Vectors 842	
	37-7 Three Magnetic Vectors 642	
38	ELECTROMAGNETIC OSCILLATIONS	851
	38-1 LC Oscillations 851	
	38-2 Analogy to Simple Harmonic Motion 855	
	38-3 Electromagnetic Oscillations-Quantitative 856	
	38-4 Forced Oscillations and Resonance 860	
	38-5 Lumped and Distributed Elements 862	
	38-6 Electromagnetic Cavity Oscillator 863	
	38-7 Induced Magnetic Fields 867	
	38-8 Displacement Current 870	
	38-9 Maxwell's Equations 871	
	38-10 Maxwell's Equations and Cavity Oscillations 871	

XIV CONTENTS

39	ELECTROMAGNETIC WAVES	879
	39-1 Transmission Line 879	
	39-2 Coaxial Cable-Fields and Currents 882	
	39-3 Waveguide 885	
	39-4 Radiation 887	
	39-5 Traveling Waves and Maxwell's Equations 890	
	39-6 The Poynting Vector 894	
40	NATURE AND PROPAGATION OF LIGHT	901
	40-1 Light and the Electromagnetic Spectrum 901	
	40-2 Energy and Momentum 903	
	40-3 The Speed of Light 906	
	40-4 Moving Sources and Observers 911	
	40-5 Doppler Effect 914	
41	REFLECTION AND REFRACTION-	
	PLANE WAVES AND PLANE SURFACES	921
	41-1 Reflection and Refraction 921	
	41-2 Huygens' Principle 926	
	41-3 Huygens' Principle and the Law of Reflection 928	
	41-4 Huygens' Principle and the Law of Refraction 929	
	41-5 Total Internal Reflection 932	
	41-6 Fermat's Principle 936	
42	REFLECTION AND REFRACTION-	
	SPHERICAL WAVES AND SPHERICAL SURFACES	943
	42-1 Geometrical Optics and Wave Optics 943	
	42-2 Spherical Waves-Plane Mirror 946	
	42-3 Spherical Waves-Spherical Mirror 949	
	42-4 Spherical Refracting Surface 957	
	42-5 Thin Lenses 963	
43	INTERFERENCE	976
	43-1 Young's Experiment 976	
	43-2 Coherence 982	
	43-3 Intensity in Young's Experiment 985	
	43-4 Adding Wave Disturbances 988	
	43-5 Interference from Thin Films 991	
	43-6 Phase Changes on Reflection 997	
	43-7 Michelson's Interferometer 998	
	43-8 Michelson's Interferometer and Light Propagation 1000	
44	DIFFRACTION	1007
	44-1 Introduction 1007	
	44-2 Single Slit 1010	
	44-3 Single Slit-Qualitative 1013	

CONTENTS	X V
CONTENTS	X V

44-4 Single Slit-Quantitative 1016	
44-5 Diffraction at a Circular Aperture 1020	
44-6 Double Slit 1023	
GRATINGS AND SPECTRA	1031
45-1 Introduction 1031	
1	
-	
-	
•	
43-0 Blagg & Law 1046	
POLARIZATION	1055
_	
-	
46-8 Double Scattering 10//	
LIGHT AND CHANTIM PHYSICS	1081
	1001
·	
-	
-	
47-9 The Correspondence Principle 1104	
WAVES AND DARTICLES	1108
	1100
48-5 The Uncertainty Principle 1118	
PENDICEC	
TENDICES .	1
NSWERS TO PROBLEMS	29
INTERNATION INCOLLING	29
DEX	37
	GRATINGS AND SPECTRA 45-1 Introduction 1031 45-2 Multiple Slits 1031 45-3 Diffraction Gratings 1036 45-4 Resolving Power of a Grating 1040 45-5 X-ray Diffraction 1042 45-6 Bragg's Law 1048 POLARIZATION 46-1 Polarization 1055 46-2 Polarizing Sheets 1058 46-3 Polarization by Reflection 1061 464 Double Refraction 1063 46-5 Circular Polarization 1071 46-6 Angular Momentum of Light 1075 46-7 Scattering of Light 1075 46-8 Double Scattering 1077 LIGHT AND QUANTUM PHYSICS 47-1 Sources of Light 1081 47-2 Cavity Radiators 1082 47-3 Planck's Radiation Formula 1085 474 Photoelectric Effect 1087 47-5 Einstein's Photon Theory 1090 47-6 The Compton Effect 1092 47-7 Line Spectra 1096 47-8 The Hydrogen Atom 1099 47-9 The Correspondence Principle 1104 WAVES AND PARTICLES 48-1 Matter Waves 1108 48-2 Atomic Structure and Standing Waves 1111 48-3 Wave Mechanics 1112 484 Meaning of Ψ 1116 48-5 The Uncertainty Principle 1118 PENDICES SWERS TO PROBLEMS