CHAPTE	r 1. The Electrostatic Field in Vacuum	1
1–1	Vector fields	1
1–2	The electric field	7
1-3	Coulomb's law	8
1-4	Coulomb's law	10
1–5	The potential in terms of charge distribution	11
1-6	Field singularities	13
1-7	Clusters of point charges	13
1-8	Dipole interactions	19
1-9	Surface singularities	20
1–10	Volume distributions of dipole moment	23
0	- 9 Demus and Conservation and Designed of Management	
Снарте		28
2–1	The displacement vector	28
2–2	Boundary conditions	31
2-3		33
2-4	Polarizability	38
Chapte		
	Problems	42
3-1	Uniqueness theorem	42
3-2	Green's reciprocation theorem	43
3-3	Solution by Green's function	44
3–4	Solution by inversion	47
3–5	Solution by electrical images	49
3-6	Solution of Laplace's equation by the separation of variables .	53
Снарте	R 4. TWO-DIMENSIONAL POTENTIAL PROBLEMS	61
4-1	Conjugate complex functions	61
4-2	Capacity and field strength	63
4-3	The potential of a uniform field	64
4-4	The potential of a line charge	64
4-5	Complex transformations	66
4-6	General Schwarz transformation	67
4-7	Single-angle transformations	70
4-8	Multiple-angle transformations	71
4-9	Direct solution of Laplace's equation by the method of harmonics	73
4-10		
		74
	Illustration: Line charge and dielectric cylinder	74 77

	r 5. Three-dimensional Potential Problems	•	81
5 - 1	The solution of Laplace's equation in spherical coordinates .		81
5-2	The potential of a point charge		82
5-3	· · ·		83
5 - 4	The potential of a dielectric sphere in a uniform field		84
5-5	The potential of an arbitrary axially-symmetric spherical		
	potential distribution		86
5 - 6	The potential of a charged ring		87
5-7	Problems not having axial symmetry		88
5-8	The solution of Laplace's equation in cylindrical coordinates		88
5-9	Application of cylindrical solutions to potential problems		91
Chapte	R 6. ENERGY RELATIONS AND FORCES IN THE ELECTRO-		
	STATIC FIELD		95
6 - 1	Field energy in free space		95
6-2	Energy density within a dielectric		98
6-3			100
6-4	Thomson's theorem		101
6-5			103
6-6	Volume forces in the electrostatic field in the presence		
00	of dielectrics		107
6-7	The behavior of dielectric liquids in an electrostatic field .		111
•••			
Снарте	R 7. STEADY CURRENTS AND THEIR INTERACTION		110
		• •	118
71		• •	
7-1	Ohm's law	•••	118
7-2	Ohm's law		118 119
7–2 7–3	Ohm's law	 	118 119 120
7-2 7-3 7-4	Ohm's law		118 119 120 122
7-2 7-3 7-4 7-5	Ohm's law	· ·	118 119 120 122 123
7-2 7-3 7-4 7-5 7-6	Ohm's law	 	118 119 120 122 123 125
7-2 7-3 7-4 7-5 7-6 7-7	Ohm's law	· ·	 118 119 120 122 123 125 125
7-2 7-3 7-4 7-5 7-6 7-7 7-8	Ohm's law	· · · · · · · · · · · · · · · · · · ·	 118 119 120 122 123 125 125 127
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9	Ohm's law	· ·	 118 119 120 122 123 125 125 127 129
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9 7-10	Ohm's law	· · · · · · · · · · · ·	 118 119 120 122 123 125 125 127 129 129
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9 7-10 7-11	Ohm's law .	· · · · · · · · · · · · · · ·	 118 119 120 122 123 125 125 127 129 130
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9 7-10 7-11 7-12	Ohm's law	· · · · · · · · · · · ·	 118 119 120 122 123 125 125 127 129 120 130 134
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9 7-10 7-11 7-12	Ohm's law .	· · · · · · · · · · · · · · ·	 118 119 120 122 123 125 125 127 129 130
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9 7-10 7-11 7-12 7-13	Ohm's law	· · · · · · · · · · · · · · ·	 118 119 120 122 123 125 125 127 129 120 130 134
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9 7-10 7-11 7-12	Ohm's law	· · · · · · · · · · · · · · · · · ·	 118 119 120 122 123 125 125 127 129 129 130 134 135
7–2 7–3 7–4 7–5 7–6 7–7 7–8 7–9 7–10 7–11 7–12 7–13 Chapte	Ohm's law . . . Electromotive force . . . The solution of stationary current problems . . Time of relaxation in a homogeneous medium . . The magnetic interaction of steady line currents . . The magnetic induction field . . . The magnetic scalar potential . . . The magnetic vector potential . . . Types of currents . . . Polarization currents . . . Magnetic moments . . . Vacuum displacement current . . . R 8. MAGNETIC MATERIALS AND BOUNDARY VALUE PROBLEMS . .		 118 119 120 122 123 125 125 127 129 120 130 134 135
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9 7-10 7-11 7-12 7-13 Chapte 8-1	Ohm's law .	· · · · · · · · · · · · · · · · · · ·	 118 119 120 122 123 125 125 127 129 130 134 135 139 139
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9 7-10 7-11 7-12 7-13 CHAPTE 8-1 8-2	Ohm's law	· · · · · · · · · · · · · · · · · · ·	 118 119 120 122 123 125 125 127 129 130 134 135 139 139
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9 7-10 7-11 7-12 7-13 Chapte 8-1	Ohm's law .	· · · · · · · · · · · · · · · · · · ·	 118 119 120 122 123 125 125 127 129 130 134 135 139 139 140
7-2 7-3 7-4 7-5 7-6 7-7 7-8 7-9 7-10 7-11 7-12 7-13 CHAPTE 8-1 8-2	Ohm's law	· · · · · · · · · · · · · · · · · · ·	 118 119 120 122 123 125 125 127 129 130 134 135 139 139

	CONTENTS	X1
0 5		
8-5	Solution of boundary value problems by magnetic scalar	146
0 0	potentials.	140
8-6	Uniqueness theorem for the vector potential	
8-7	The use of the vector potential in the solution of problems	148
8-8	The vector potential in two dimensions	151
8–9	The vector potential in cylindrical coordinates	153
CHAPTE	r 9. Maxwell's Equations	158
9-1	Faraday's law of induction	158
9-2	Maxwell's equations for stationary media	159
93	Faraday's law for moving media	160
9–4	Maxwell's equations for moving media	163
9-5	Motion of a conductor in a magnetic field	165
	, i i i i i i i i i i i i i i i i i i i	
Снарте		
	THE ELECTROMAGNETIC FIELD	170
10-1	Energy relations in quasi-stationary current systems	170
10-2	Forces on current systems	172
10-3	Inductance	174
10-4	Magnetic volume force	177
10-5	General expressions for electromagnetic energy	178
10-6	Momentum balance	181
Chapte	r 11. The Wave Equation and Plane Waves	185
11–1	The wave equation	185
11-2	Plane waves	187
11-3	Radiation pressure	191
11-4	Plane waves in a moving medium	193
11-5	Reflection and refraction at a plane boundary	
116	Waves in conducting media and metallic reflection	200
11-7	Group velocity	202
		202
Chapte	r 12. Conducting Fluids in a Magnetic Field	
	(Magnetohydrodynamics)	205
12-1	"Frozen-in" lines of force	205
12-2	Magnetohydrodynamic waves	207
		201
Снарте	r 13. Waves in the Presence of Metallic Boundaries .	212
13-1	The nature of metallic boundary conditions	212
13-2	Eigenfunctions and eigenvalues of the wave equation	214
13-3	Cavities with rectangular boundaries	218
13-4	Cylindrical cavities	219
13-5	Circular cylindrical cavities	000
13-6	Wave guides	
13-7	Scattering by a circular cylinder	226

х

13-8	Spherical waves	. 229
13-9	Scattering by a sphere	. 233
~		240
CHAPTE:		· 240
14-1	The wave equation for the potentials	. 240
14 - 2	Solution by Fourier analysis	. 242
14-3	The radiation fields	. 245
14-4	Radiated energy	. 248
14 - 5	The Hertz potential	. 254
14-6	Computation of radiation fields by the Hertz method	. 255
14-7	Electric dipole radiation	
14-8	Multipole radiation	
14-9	Derivation of multipole radiation from scalar superpotentials	
14-10	Energy and angular momentum radiated by multipoles	. 267
a		
Chapte		070
	Special Relativity	
15-1		. 272
15 - 2	The search for an absolute ether frame	. 274
15 - 3	The Lorentz-Fitzgerald contraction hypothesis	
15 - 4	"Ether drag"	. 279
15 - 5	Emission theories	
15-6	Summary	. 283
~		
Снарте		000
	TRANSFORMATION	. 286
16-1	The velocity of light and simultaneity	
16-2	Kinematic relations in special relativity	
16-3	The Lorentz transformation	. 293
16 - 4	Geometric interpretations of the Lorentz transformation	
16 - 5	Transformation equations for velocity	. 301
~		005
Снарте		. 305
17-1	The Lorentz transformation of a four-vector	. 305
17 - 2	Some tensor relations useful in special relativity	. 307
17 - 3	The conservation of momentum	
17-4	Relation of energy to momentum and to mass	
17 - 5	The Minkowski force	
17-6	The collision of two similar particles	. 318
17-7	The use of four-vectors in calculating kinematic relations	
	for collisions	. 320
		001
Chapte		
Снарте 18–1	The four-vector potential	. 324
	The four-vector potential	. 324 . 327
18-1	The four-vector potential	. 324 . 327

	CONTENTS	xiii
18-4	Covariant description of sources in material media	332
18 - 5	The field equations in a material medium	334
18-6	Transformation properties of the partial fields	336
Снартер		
	OF A UNIFORMLY MOVING ELECTRON	341
19–1	The Liénard-Wiechert potentials	341
19–2	The fields of a charge in uniform motion	344
19-3	Direct solution of the wave equation	347
19-4	The "convection potential"	348
19–5	The virtual photon concept	350
Снартер	R 20. RADIATION FROM AN ACCELERATED CHARGE	354
20-1	Fields of an accelerated charge	354
20-2	Radiation at low velocity	358
20-3	The case of $\dot{\mathbf{u}}$ parallel to \mathbf{u}	359
20-4	Radiation when the acceleration is perpendicular to the	
	velocity (radiation from circular orbits)	363
20 - 5	Radiation with no restrictions on the acceleration or velocity	370
20-6	Classical cross section for bremsstrahlung in a Coulomb field .	371
20-7	Čerenkov radiation	373
Снартеі	21. RADIATION REACTION AND COVARIANT FORMULATION OF THE CONSERVATION LAWS OF ELECTRODYNAMICS	377
21–1	Covariant formulation of the conservation laws of vacuum electrodynamics	077
21-2	Transformation properties of the "free" radiation field	377 379
21-2 21-3	The electromagnetic energy momentum tensor in material media	379 380
21 - 3 21 - 4	Electromagnetic mass	380 381
21 - 4 21-5	Electromagnetic mass—qualitative considerations	383
21-6	The reaction necessary to conserve radiated energy	386
21-7	Direct computation of the radiation reaction from the	
01 0	retarded fields	387
21-8	Properties of the equation of motion	389
21–9	Covariant description of the mechanical properties of the	000
01 10	electromagnetic field of a charge	390
	The relativistic equations of motion	392
21-11	The integration of the relativistic equation of motion Modification of the theory of radiation to eliminate divergent	394
21-12	mass integrals. Advanced potentials	204
91_13		394 398
		990
	22. RADIATION, SCATTERING, AND DISPERSION	401
22-1	Radiative damping of a charged harmonic oscillator	401
22-2	Forced vibrations	403
22 - 3	Scattering by an individual free electron	404

xii

22-4 Scattering by a bound electron	407
22-5 Absorption of radiation by an oscillator	407
22-6 Equilibrium between an oscillator and a radiation field	409
22-7 Effect of a volume distribution of scatterers	411
22-8 Scattering from a volume distribution. Rayleigh scattering	414
22-9 The dispersion relation	416
22–10 A general theorem on scattering and absorption	419
CHAPTER 23. THE MOTION OF CHARGED PARTICLES IN ELECTRO-	105
MAGNETIC FIELDS	425
23–1 World-line description	425
23–2 Hamiltonian formulation and the transition to three-	
dimensional formalism	427
23-3 Equations for the trajectories	430
23–4 Applications	433
23-5 The motion of a particle with magnetic moment in an	
electromagnetic field	437
	440
CHAPTER 24. HAMILTONIAN FORMULATION OF MAXWELL'S EQUATIONS	446
24–1 Transition to a one-dimensional continuous system	446
24–2 Generalization to a three-dimensional continuum	448
24–3 The electromagnetic field	451
24-4 Periodic solutions in a box. Plane wave representation	454
Appendix I. Units and Dimensions in Electromagnetic Theory .	459
Tables: I-1. Conversion Factors 	465
I-2. Fundamental Electromagnetic Relations Valid in vacuo as	
They Appear in the Various Systems of Units	466
I-3. Definition of Fields from Sources (mks system)	468
I-4. Useful Numerical Relations	469
Appendix II. Useful Vector Relations	470
Table II-1. Vector Formulas 	470
APPENDIX III. VECTOR RELATIONS IN CURVILINEAR COORDINATES.	473
	475
Table III-1. Coordinate Systems 	470
Bibliography	479
Index	485

xiv