
CONTENTS

Preface to the third edition of Volume 2	xiii
Preface to the second edition of Volume 2	xvii
Preface to the first edition of Volume 2	xxi
CHAPTER 1	
ELECTROSTATICS: CHARGES AND FIELDS	1
1.1 Electric charge	1
1.2 Conservation of charge	4
1.3 Quantization of charge	5
1.4 Coulomb's law	7
1.5 Energy of a system of charges	11
1.6 Electrical energy in a crystal lattice	14
1.7 The electric field	16
1.8 Charge distributions	20
1.9 Flux	22
1.10 Gauss's law	23
1.11 Field of a spherical charge distribution	26
1.12 Field of a line charge	28
1.13 Field of an infinite flat sheet of charge	29
1.14 The force on a layer of charge	30
1.15 Energy associated with the electric field	33
1.16 Applications	35

Chapter summary	38
Problems	39
Exercises	47
CHAPTER 2	
THE ELECTRIC POTENTIAL	58
2.1 Line integral of the electric field	59
2.2 Potential difference and the potential function	61
2.3 Gradient of a scalar function	63
2.4 Derivation of the field from the potential	65
2.5 Potential of a charge distribution	65
2.6 Uniformly charged disk	68
2.7 Dipoles	73
2.8 Divergence of a vector function	78
2.9 Gauss's theorem and the differential form of Gauss's law	79
2.10 The divergence in Cartesian coordinates	81
2.11 The Laplacian	85
2.12 Laplace's equation	86
2.13 Distinguishing the physics from the mathematics	88
2.14 The curl of a vector function	90
2.15 Stokes' theorem	92
2.16 The curl in Cartesian coordinates	93
2.17 The physical meaning of the curl	95
2.18 Applications	100
Chapter summary	103
Problems	105
Exercises	112
CHAPTER 3	
ELECTRIC FIELDS AROUND CONDUCTORS	124
3.1 Conductors and insulators	125
3.2 Conductors in the electrostatic field	126
3.3 The general electrostatic problem and the uniqueness theorem	132
3.4 Image charges	136
3.5 Capacitance and capacitors	141
3.6 Potentials and charges on several conductors	147
3.7 Energy stored in a capacitor	149
3.8 Other views of the boundary-value problem	151
3.9 Applications	153
Chapter summary	155

Problems	155
Exercises	163
CHAPTER 4	
ELECTRIC CURRENTS	177
4.1 Electric current and current density	177
4.2 Steady currents and charge conservation	180
4.3 Electrical conductivity and Ohm's law	181
4.4 The physics of electrical conduction	189
4.5 Conduction in metals	198
4.6 Semiconductors	200
4.7 Circuits and circuit elements	204
4.8 Energy dissipation in current flow	207
4.9 Electromotive force and the voltaic cell	209
4.10 Networks with voltage sources	212
4.11 Variable currents in capacitors and resistors	215
4.12 Applications	217
Chapter summary	221
Problems	222
Exercises	226
CHAPTER 5	
THE FIELDS OF MOVING CHARGES	235
5.1 From Oersted to Einstein	236
5.2 Magnetic forces	237
5.3 Measurement of charge in motion	239
5.4 Invariance of charge	241
5.5 Electric field measured in different frames of reference	243
5.6 Field of a point charge moving with constant velocity	247
5.7 Field of a charge that starts or stops	251
5.8 Force on a moving charge	255
5.9 Interaction between a moving charge and other moving charges	259
Chapter summary	267
Problems	268
Exercises	270
CHAPTER 6	
THE MAGNETIC FIELD	277
6.1 Definition of the magnetic field	278
6.2 Some properties of the magnetic field	286

6.3	Vector potential	293
6.4	Field of any current-carrying wire	296
6.5	Fields of rings and coils	299
6.6	Change in \mathbf{B} at a current sheet	303
6.7	How the fields transform	306
6.8	Rowland's experiment	314
6.9	Electrical conduction in a magnetic field: the Hall effect	314
6.10	Applications	317
	Chapter summary	322
	Problems	323
	Exercises	331
CHAPTER 7		
ELECTROMAGNETIC INDUCTION		342
7.1	Faraday's discovery	343
7.2	Conducting rod moving through a uniform magnetic field	345
7.3	Loop moving through a nonuniform magnetic field	346
7.4	Stationary loop with the field source moving	352
7.5	Universal law of induction	355
7.6	Mutual inductance	359
7.7	A reciprocity theorem	362
7.8	Self-inductance	364
7.9	Circuit containing self-inductance	366
7.10	Energy stored in the magnetic field	368
7.11	Applications	369
	Chapter summary	373
	Problems	374
	Exercises	380
CHAPTER 8		
ALTERNATING-CURRENT CIRCUITS		388
8.1	A resonant circuit	388
8.2	Alternating current	394
8.3	Complex exponential solutions	402
8.4	Alternating-current networks	405
8.5	Admittance and impedance	408
8.6	Power and energy in alternating-current circuits	415
8.7	Applications	418
	Chapter summary	420
	Problems	421
	Exercises	424

CHAPTER 9		
MAXWELL'S EQUATIONS AND ELECTROMAGNETIC WAVES		430
9.1	"Something is missing"	430
9.2	The displacement current	433
9.3	Maxwell's equations	436
9.4	An electromagnetic wave	438
9.5	Other waveforms; superposition of waves	441
9.6	Energy transport by electromagnetic waves	446
9.7	How a wave looks in a different frame	452
9.8	Applications	454
	Chapter summary	455
	Problems	457
	Exercises	461
CHAPTER 10		
ELECTRIC FIELDS IN MATTER		466
10.1	Dielectrics	467
10.2	The moments of a charge distribution	471
10.3	The potential and field of a dipole	474
10.4	The torque and the force on a dipole in an external field	477
10.5	Atomic and molecular dipoles; induced dipole moments	479
10.6	Permanent dipole moments	482
10.7	The electric field caused by polarized matter	483
10.8	Another look at the capacitor	489
10.9	The field of a polarized sphere	492
10.10	A dielectric sphere in a uniform field	495
10.11	The field of a charge in a dielectric medium, and Gauss's law	497
10.12	A microscopic view of the dielectric	500
10.13	Polarization in changing fields	504
10.14	The bound-charge current	505
10.15	An electromagnetic wave in a dielectric	507
10.16	Applications	509
	Chapter summary	511
	Problems	513
	Exercises	516
CHAPTER 11		
MAGNETIC FIELDS IN MATTER		523
11.1	How various substances respond to a magnetic field	524

CONTENTS

11.2	The absence of magnetic “charge”	529
11.3	The field of a current loop	531
11.4	The force on a dipole in an external field	535
11.5	Electric currents in atoms	540
11.6	Electron spin and magnetic moment	546
11.7	Magnetic susceptibility	549
11.8	The magnetic field caused by magnetized matter	551
11.9	The field of a permanent magnet	557
11.10	Free currents, and the field H	559
11.11	Ferromagnetism	565
11.12	Applications	570
	Chapter summary	573
	Problems	575
	Exercises	577
CHAPTER 12		
	SOLUTIONS TO THE PROBLEMS	586
12.1	Chapter 1	586
12.2	Chapter 2	611
12.3	Chapter 3	636
12.4	Chapter 4	660
12.5	Chapter 5	678
12.6	Chapter 6	684
12.7	Chapter 7	707
12.8	Chapter 8	722
12.9	Chapter 9	734
12.10	Chapter 10	744
12.11	Chapter 11	755
Appendix A:		
	Differences between SI and Gaussian units	762
Appendix B:		
	SI units of common quantities	769
Appendix C:		
	Unit conversions	774
Appendix D:		
	SI and Gaussian formulas	778
Appendix E:		
	Exact relations among SI and Gaussian units	789

Appendix F: Curvilinear coordinates	791
Appendix G: A short review of special relativity	804
Appendix H: Radiation by an accelerated charge	812
Appendix I: Superconductivity	817
Appendix J: Magnetic resonance	821
Appendix K: Helpful formulas/facts	825
References	831
Index	833