

Contents

Introducing the Illinois ECE Series	xiii
Preface	xvii
About the Author	xxi
A Tribute to Edward C. Jordan	xxiii
PART 1 Essential Elements for Electrical and Computer Engineering	1
CHAPTER 1 Vectors and Fields	3
1.1 Vector Algebra	3
1.2 Cartesian Coordinate System	12
1.3 Cylindrical and Spherical Coordinate Systems	20
1.4 Scalar and Vector Fields	27
1.5 The Electric Field	32
1.6 The Magnetic Field	46
1.7 Lorentz Force Equation	58
Summary	63
Review Questions	66
Problems	68
Review Problems	75
CHAPTER 2 Maxwell's Equations in Integral Form	77
2.1 The Line Integral	77
2.2 The Surface Integral	84
2.3 Faraday's Law	90
2.4 Ampère's Circuital Law	101
2.5 Gauss' Laws	106
2.6 The Law of Conservation of Charge	110

2.7	Application to Static Fields	113
	Summary	119
	Review Questions	121
	Problems	122
	Review Problems	127
CHAPTER 3	Maxwell's Equations in Differential Form, and Uniform Plane Waves in Free Space	129
3.1	Faraday's Law and Ampère's Circuital Law	130
3.2	Gauss' Laws and the Continuity Equation	141
3.3	Curl and Divergence	149
3.4	Uniform Plane Waves in Time Domain in Free Space	160
3.5	Sinusoidally Time-Varying Uniform Plane Waves in Free Space	171
3.6	Polarization of Sinusoidally Time-Varying Vector Fields	178
3.7	Power Flow and Energy Storage	184
	Summary	191
	Review Questions	195
	Problems	197
	Review Problems	204
CHAPTER 4	Fields and Waves in Material Media	207
4.1	Conductors and Semiconductors	207
4.2	Dielectrics	217
4.3	Magnetic Materials	227
4.4	Wave Equation and Solution for Material Medium	239
4.5	Uniform Plane Waves in Dielectrics and Conductors	250
4.6	Boundary Conditions	255
4.7	Reflection and Transmission of Uniform Plane Waves	263
	Summary	267
	Review Questions	270
	Problems	272
	Review Problems	279
CHAPTER 5	Electromagnetic Potentials and Topics for Circuits and Systems	282
5.1	Gradient, Laplacian, and the Potential Functions	282
5.2	Potential Functions for Static Fields	290
5.3	Poisson's and Laplace's Equations	299
5.4	Capacitance, Conductance, and Inductance	308
5.5	Electric- and Magnetic-Field Systems	320

5.6	Magnetic Circuits	332
5.7	Electromechanical Energy Conversion	339
	Summary	345
	Review Questions	348
	Problems	349
	Review Problems	357
CHAPTER 6	Transmission-Line Essentials for Digital Electronics	359
6.1	Transmission Line	359
6.2	Line Terminated by Resistive Load	372
6.3	Transmission-Line Discontinuity	385
6.4	Lines with Reactive Terminations and Discontinuities	394
6.5	Lines with Initial Conditions	399
6.6	Interconnections between Logic Gates	405
6.7	Crosstalk on Transmission Lines	411
	Summary	418
	Review Questions	422
	Problems	423
	Review Problems	433
PART 2	Essential/Elective Elements	437
CHAPTER 7	Transmission Lines for Communications	439
7.1	Short-Circuited Line	440
7.2	Line Terminated by Arbitrary Load	450
7.3	Transmission-Line Matching	463
7.4	The Smith Chart: 1. Basic Procedures	472
7.5	The Smith Chart: 2. Applications	479
7.6	The Lossy Line	488
7.7	Pulses on Lossy Lines	498
	Summary	506
	Review Questions	509
	Problems	510
	Review Problems	523
CHAPTER 8	Guided Wave Principles for Electronics and Optoelectronics	527
8.1	Uniform Plane Wave Propagation in an Arbitrary Direction	527
8.2	TE and TM Waves in a Parallel-Plate Waveguide	536
8.3	Transmission-Line Equivalents	545
8.4	Dispersion and Group Velocity	548

8.5	Reflection and Refraction of Plane Waves	555
8.6	Dielectric Slab Guide	566
8.7	Ray Tracing and Graded-Index Guide	578
	Summary	586
	Review Questions	590
	Problems	592
	Review Problems	599
CHAPTER 9	Several Topics for Electronics and Photonics	600
9.1	Rectangular Metallic Waveguide and Cavity Resonator	600
9.2	Cylindrical Metallic Waveguide and Cavity Resonator	613
9.3	Losses in Metallic Waveguides and Resonators	624
9.4	Optical Fiber	633
9.5	Pulse Broadening in Dispersive Medium	639
9.6	Interference and Diffraction	646
9.7	Wave Propagation in Anisotropic Medium	654
	Summary	662
	Review Questions	664
	Problems	665
	Review Problems	672
CHAPTER 10	Principles of Radiation and Antennas	675
10.1	Hertzian Dipole	675
10.2	Radiation Resistance and Directivity	682
10.3	Linear Antennas	688
10.4	Antenna Arrays	694
10.5	Antennas in the Presence of Reflectors	702
10.6	Aperture Antennas	706
10.7	Receiving Properties	710
	Summary	716
	Review Questions	718
	Problems	719
	Review Problems	724
CHAPTER 11	Several Solution Techniques	726
11.1	Analytical Solution of Laplace's Equation	726
11.2	Numerical Solution by Finite-Difference Method	732
11.3	Method of Moments	739
11.4	Determination of Transmission-Line Parameters	744

11.5 Solution by Field Mapping	748
11.6 Finite-Element Method	751
11.7 Finite-Difference Time-Domain Method	760
Summary	765
Review Questions	767
Problems	768
Review Problems	776
APPENDICES	
A. Complex Numbers and Phasor Technique	779
B. Curl, Divergence, Gradient, and Laplacian in Cylindrical and Spherical Coordinate Systems	788
C. Units and Dimensions	795
Suggested Collateral and Further Reading	800
Answers to Selected Problems	801
Index	812