## **Contents**

CHAPTER 1	The Subject of Electromagnetics	1
	1.1 Historical Background 1.2 Objectives of the Chapter 1.3 Electric Charge 1.4 Units 1.5 Vectors 1.6 Electrical Force, Field, Flux, and Potential 1.7 Magnetic Force, Field, Flux, and Potential 1.8 Electromagnetic Induction 1.9 Mathematical Operators and Identities 1.10 Maxwell's Equations 1.11 Electromagnetic Waves 1.12 Trajectory of a Sinusoidal Motion in Two Dimensions 1.13 Wave Polarization 1.14 Electromagnetic Spectrum 1.15 Transmission Lines	
CHAPTER 2	Vector Analysis	31
	<ul><li>2.1 Introduction 2.2 Vector Notation 2.3 Vector Functions 2.4 Vector Algebra</li><li>2.5 Coordinate Systems 2.6 Differential Volume, Surface, and Line Elements</li></ul>	
CHAPTER 3	Electric Field	44
	<ul> <li>3.1 Introduction 3.2 Coulomb's Law in Vector Form 3.3 Superposition</li> <li>3.4 Electric Field Intensity 3.5 Charge Distributions 3.6 Standard Charge Configurations</li> </ul>	
CHAPTER 4	Electric Flux	63
	<ul> <li>4.1 Net Charge in a Region 4.2 Electric Flux and Flux Density 4.3 Gauss's Law</li> <li>4.4 Relation between Flux Density and Electric Field Intensity 4.5 Special Gaussian Surfaces</li> </ul>	
CHAPTER 5	Gradient, Divergence, Curl, and Laplacian	78
	<ul> <li>5.1 Introduction 5.2 Gradient 5.3 The Del Operator 5.4 The Del Operator and Gradient 5.5 Divergence 5.6 Expressions for Divergence in Coordinate Systems</li> <li>5.7 The Del Operator and Divergence 5.8 Divergence of D 5.9 The Divergence Theorem 5.10 Curl 5.11 Laplacian 5.12 Summary of Vector Operations</li> </ul>	
CHAPTER 6	Electrostatics: Work, Energy, and Potential	97
	<b>6.1</b> Work Done in Moving a Point Charge <b>6.2</b> Conservative Property of the Electrostatic Field <b>6.3</b> Electric Potential between Two Points <b>6.4</b> Potential of a Point Charge <b>6.5</b> Potential of a Charge Distribution <b>6.6</b> Relationship between E and V <b>6.7</b> Energy in Static Electric Fields	

CHAPTER 7	Electric Current	113
	<ul> <li>7.1 Introduction 7.2 Charges in Motion 7.3 Convection Current Density J</li> <li>7.4 Conduction Current Density J 7.5 Concductivity σ 7.6 Current I</li> <li>7.7 Resistance R 7.8 Current Sheet Density K 7.9 Continuity of Current</li> <li>7.10 Conductor-Dielectric Boundary Conditions</li> </ul>	
CHAPTER 8	Capacitance and Dielectric Materials	131
	<b>8.1</b> Polarization <b>P</b> and Relative Permittivity $\epsilon_r$ <b>8.2</b> Capacitance <b>8.3</b> Multiple-Dielectric Capacitors <b>8.4</b> Energy Stored in a Capacitor <b>8.5</b> Fixed-Voltage <b>D</b> and <b>E 8.6</b> Fixed-Charge <b>D</b> and <b>E 8.7</b> Boundary Conditions at the Interface of Two Dielectrics <b>8.8</b> Method of Images	,
CHAPTER 9	Laplace's Equation	151
	<ul> <li>9.1 Introduction 9.2 Poisson's Equation and Laplace's Equation 9.3 Explicit Forms of Laplace's Equation 9.4 Uniqueness Theorem 9.5 Mean Value and Maximum Value Theorems 9.6 Cartesian Solution in One Variable 9.7 Cartesian Product Solution 9.8 Cylindrical Product Solution 9.9 Spherical Product Solution</li> </ul>	
CHAPTER 10	Magnetic Filed and Boundary Conditions	172
	<ul> <li>10.1 Introduction 10.2 Biot-Savart Law 10.3 Ampere's Law 10.4 Relationship of J and H 10.5 Magnetic Flux Density B 10.6 Boundary Relations for Magnetic Fields 10.7 Current Sheet at the Boundary 10.8 Summary of Boundary Conditions 10.9 Vector Magnetic Potential A 10.10 Stokes' Theorem</li> </ul>	
CHAPTER 11	Forces and Torques in Magnetic Fields	193
	11.1 Magnetic Force on Particles 11.2 Electric and Magnetic Fields Combined 11.3 Magnetic Force on a Current Element 11.4 Work and Power 11.5 Torque 11.6 Magnetic Moment of a Planar Coil	
CHAPTER 12	Inductance and Magnetic Circuits	209
	12.1 Inductance 12.2 Standard Conductor Configurations 12.3 Faraday's Law and Self-Inductance 12.4 Internal Inductance 12.5 Mutual Inductance 12.6 Magnetic Circuits 12.7 The B-H Curve 12.8 Ampere's Law for Magnetic Circuits 12.9 Cores with Air Gaps 12.10 Multiple Coils 12.11 Parallel Magnetic Circuits	
CHAPTER 13	Time-Varying Fields and Maxwell's Equations	233
	13.1 Introduction 13.2 Maxwell's Equations for Static Fields 13.3 Faraday's Law and Lenz's Law 13.4 Conductors' Motion in Time-Independent Fields 13.5 Conductors' Motion in Time-Dependent Fields 13.6 Displacement Current 13.7 Ratio of $J_C$ to $J_D$ 13.8 Maxwell's Equations for Time-Varying Fields	
CHAPTER 14	Electromagnetic Waves	251
	<b>14.1</b> Introduction <b>14.2</b> Wave Equations <b>14.3</b> Solutions in Cartesian Coordinates <b>14.4</b> Plane Waves <b>14.5</b> Solutions for Partially Conducting Media <b>14.6</b> Solutions for Perfect Dielectrics <b>14.7</b> Solutions for Good Conductors: Skin Depth	

	<ul> <li>14.8 Interface Conditions at Normal Incidence 14.9 Oblique Incidence and Snell's Laws 14.10 Perpendicular Polarization 14.11 Parallel Polarization</li> <li>14.12 Standing Waves 14.13 Power and the Poynting Vector</li> </ul>	
CHAPTER 15	Transmission Lines	273
	<ul> <li>15.1 Introduction 15.2 Distributed Parameters 15.3 Incremental Models</li> <li>15.4 Transmission Line Equation 15.5 Sinusoidal Steady-State Excitation</li> <li>15.6 Sinusoidal Steady-State in Lossless Lines 15.7 The Smith Chart</li> <li>15.8 Impedance Matching 15.9 Single-Stub Matching 15.10 Double-Stub</li> <li>Matching 15.11 Impedance Measurement 15.12 Transients in Lossless Lines</li> </ul>	
CHAPTER 16	Waveguides	311
	16.1 Introduction 16.2 Transverse and Axial Fields 16.3 TE and TM Modes; Wave Impedances 16.4 Determination of the Axial Fields 16.5 Mode Cutoff Frequencies 16.6 Dominant Mode 16.7 Power Transmitted in a Lossless Waveguide 16.8 Power Dissipation in a Lossy Waveguide	
CHAPTER 17	Antennas	330
	17.1 Introduction 17.2 Current Source and the E and H Fields 17.3 Electric (Hertzian) Dipole Antenna 17.4 Antenna Parameters 17.5 Small Circular-Loop Antenna 17.6 Finite-Length Dipole 17.7 Monopole Antenna 17.8 Self- and Mutual Impedances 17.9 The Receiving Antenna 17.10 Linear Arrays 17.11 Reflectors	
APPENDIX		349
INDEX		350