

Contents

	Preface	page ix
1	Basis of electrostatics	1
1.1	<i>Nature of electric charge</i>	1
1.2	<i>Coulomb's Law</i>	1
1.3	<i>Electric intensity</i>	3
1.4	<i>Electric displacement and Gauss's Law</i>	5
1.5	<i>Electrostatic potential</i>	6
1.51	Equipotentials	12
1.52	Earnshaw's Theorem	14
1.6	<i>Special electrostatic fields</i>	14
1.61	Uniformly charged spherical surface	14
1.62	Field due to line charge	18
1.63	Dipole	20
1.631	Volume and surface distribution of dipole	22
1.64	Fields at great distances	24
1.65	Uniform field	25
2	Dielectrics and energy	29
2.1	<i>Nature of dielectric</i>	29
2.11	Equations governing field within dielectric	30
2.12	Surface distributions of charge	33
2.2	<i>Energy of an electrostatic field</i>	35
2.21	Symmetry of constitutive equations for crystals	37
2.3	<i>Systems of conductors</i>	39
2.31	Electric screening	40
2.32	Condensers	42
2.321	Combinations of condensers	47
2.33	Capacity of two distant conductors	49
2.34	Green's Reciprocal Theorem	50
2.35	Kelvin's Theorem	51
2.4	<i>Stress in electrostatic systems</i>	52
3.	Solution of electrostatic problems	56

vi Contents

3.1	<i>Boundary value problems and the Uniqueness theorem</i>	56
3.11	Green's function	58
3.2	<i>Electrostatic images</i>	59
3.21	Images in conducting plane	61
3.22	Images in a dielectric half space	63
3.3	<i>Laplace's equation</i>	64
3.31	Laplace's equation in rectangular Cartesian coordinates	66
3.32	Laplace's equation in cylindrical polar coordinates	67
3.321	Inversion in a cylinder	72
3.33	Laplace's equation in spherical polar coordinates	74
3.331	Inversion in a sphere	77
4.	Steady currents	83
4.1	<i>Introduction</i>	83
4.11	Equation of continuity	85
4.12	Electromotive force	85
4.13	Ohm's law	86
4.14	Heuristic derivation of Ohm's law.	89
4.2	<i>Steady current problems</i>	90
4.21	Dissipation of energy	92
4.22	Minimum heat theorem	93
4.23	Current sheets	94
4.3	<i>Networks involving resistances</i>	97
4.31	Kirchoff's laws	100
4.32	Reciprocity theorems	104
4.33	Minimum heat theorem	106
4.34	Telegraph wire with faults	107
4.341	Lossy cable	110
5.	Magnetic fields	115
5.1	<i>Experimental basis</i>	115
5.2	<i>Biot Savart Law</i>	115
5.21	Vector potential	119
5.22	Behaviour of small current loops	121
5.3	<i>Scalar Magnetic Potential</i>	125
5.31	Circuital law	126
5.32	Magnetic shell	130
5.33	Magnetic field	131
5.4	<i>Force between two circuits</i>	132
5.5	<i>Fields associated with magnetized media</i>	135
5.51	Constitutive relations	138
5.52	Equations governing fields within magnetic media	139

6.	Electromagnetic energy and electromagnetic induction	146
6.1	<i>Mutual energy of two current distributions</i>	146
6.11	Energy associated with a current distribution	148
6.12	Energy of a magnet in a field	150
6.2	<i>Currents in wires</i>	152
6.21	Energy of a simple circuit	158
6.22	Relation between self and mutual inductance	161
6.3	<i>Faraday's law of electromagnetic induction</i>	161
6.31	Relation between E and B for moving frames	163
6.32	Scalar and vector potential	164
6.33	Energy balance in electromagnetic induction	164
7.	Network theory	167
7.1	<i>General concept of networks</i>	167
7.11	Kirchoff's laws for general networks	169
7.12	Energy balance in networks	172
7.13	Normal modes	175
7.14	Perfectly coupled circuits	178
7.15	Transmission line	179
7.2	<i>Alternating currents</i>	182
7.21	Impedances and admittances	183
7.22	Power expended in generator	185
7.23	General theorems on AC networks	187
7.24	Filter circuits	190
7.25	Transmission line	191
7.3	<i>Arbitrary excitation of circuits</i>	193
7.31	Hereditary principle	196
7.32	Impossibility of perfect filter	196
8.	Maxwell's equations	200
8.1	<i>Time varying fields</i>	200
8.2	<i>Differential equations for E and H</i>	202
8.21	Electromagnetic potentials	206
8.22	Energy balance in electromagnetic fields	210
8.23	Stress systems associated with the electromagnetic field	213
8.24	Boundary conditions	214
8.25	Ohmic media	218
8.26	Alternating fields	219
8.3	<i>Plane waves in unbounded isotropic media</i>	222
8.31	Normal reflection of plane wave	226
8.32	Reflection and refraction of plane waves at a plane interface	229
8.4	<i>Postulation of Maxwell's equations</i>	235

viii **Contents**

9	Miscellaneous topics	241
9.1	<i>Variational principles</i>	241
9.1.1	Variational principles in electrostatics	243
9.2	<i>Superconductivity</i>	250
9.3	<i>Non-conservation of charge</i>	256
9.4	<i>Units</i>	259
	Appendix	265
	Index	270