

Contents

Part I Static Electric Phenomena

1	Electrostatic Field	3
1.1	Electric Charge in Vacuum	3
1.2	Coulomb's Law	4
1.3	Electric Field	7
1.4	Gauss' Law	11
1.5	Electric Potential	16
1.6	Electric Dipole.....	23
	Exercises	29
2	Conductors	33
2.1	Electric Properties of Conductors	33
2.2	Special Solution Method for Electrostatic Field	41
2.3	Electrostatic Induction	46
	Exercises	51
3	Conductor Systems in Vacuum	55
3.1	Coefficients in Conductor System	55
3.2	Capacitor.....	60
3.3	Electrostatic Energy	65
3.4	Electrostatic Force.....	70
	Exercises	73
4	Dielectric Materials	75
4.1	Electric Polarization.....	75
4.2	Electric Flux Density	81
4.3	Boundary Conditions.....	85
4.4	Electrostatic Energy in Dielectric Materials	92
	Exercises	95

5	Steady Current	99
5.1	Current	99
5.2	Ohm's Law	101
5.3	Microscopic Investigation of Electric Resistance.....	103
5.4	Fundamental Equations for Steady Electric Current.....	106
5.5	Electromotive Force	112
5.6	Kirchhoff's Law	114
	Exercises	117
 Part II Static Magnetic Phenomena		
6	Current and Magnetic Flux Density	123
6.1	Magnetic Flux Density by Current	123
6.2	The Biot–Savart Law	125
6.3	Force on Current	128
6.4	Magnetic Flux Lines	133
6.5	Ampere's Law	134
6.6	Vector Potential	139
6.7	Small Closed Current	144
6.8	Magnetic Charge	146
	Exercises	152
7	Superconductors	155
7.1	Magnetic Properties of Superconductors.....	155
7.2	Special Solution Method for Magnetic Flux Density.....	163
7.3	Magnetization	167
	Exercises	174
8	Current Systems	177
8.1	Inductance	177
8.2	Coils	183
8.3	Magnetic Energy	188
8.4	Magnetic Force	193
	Exercises	196
9	Magnetic Materials	201
9.1	Magnetization	201
9.2	Magnetic Field.....	208
9.3	Boundary Conditions.....	211
9.4	Magnetic Energy in Magnetic Material	220
9.5	Analogy Between Electric and Magnetic Phenomena.....	222
	Exercises	226

Part III Time-Dependent Electromagnetic Phenomena

10	Electromagnetic Induction	231
10.1	Induction Law	231
10.2	Potential	240
10.3	Boundary Conditions.....	241
10.4	Magnetic Energy	242
10.5	Skin Effect	245
	Exercises	251
11	Displacement Current and Maxwell's Equations	255
11.1	Displacement Current	255
11.2	Maxwell's Equations	258
11.3	Boundary Conditions.....	261
11.4	Electromagnetic Potential.....	261
11.5	The Poynting Vector	263
	Exercises	267
12	Electromagnetic Wave	271
12.1	Planar Electromagnetic Wave.....	271
12.2	Reflection and Refraction of the Planar Electromagnetic Wave ...	275
12.3	Energy of the Electromagnetic Wave.....	280
12.4	Wave Guide.....	281
12.5	Spherical Wave	285
12.6	Retarded Potential	287
	Exercises	289
Appendix A		291
A1	Vector Analysis.....	291
A1.1	Scalars and Vectors	291
A1.2	Addition of Vectors	291
A1.3	Products of Vectors and Scalars.....	293
A1.4	Analytic Expression of a Vector	293
A1.5	Products of Vectors	294
A1.6	Differentiation of Vectors	295
A1.7	Gradient of a Scalar.....	297
A1.8	<i>Divergence of a Vector</i>	297
A1.9	Rotation of a Vector	298
A1.10	Differentiation of Products of Vectors	299
A1.11	Second Differentiation	299
A1.12	Curvilinear Integral of a Vector	300
A1.13	Surface Integral of a Vector	301
A1.14	Gauss' Theorem	302

A1.15	Stokes' Theorem	304
A1.16	Green's Theorem	306
A1.17	Cylindrical Coordinates	307
A1.18	Polar Coordinates	308
A2	Proofs	309
A2.1	Proof of Eq. (1.37)	309
A2.2	Proof of Eq. (6.21)	310
A2.3	Proof of Eq. (6.27)	311
A2.4	Proof of Eq. (6.33)	312
A2.5	Proof of Eq. (6.45)	312
A2.6	Proof of Eq. (9.5)	313
A3	Superconductivity	314
A3.1	Phenomenological Electromagnetism	314
A3.2	Mixed State	317
A3.3	Motion of Quantized Magnetic Flux	319
A3.4	Electromagnetism and Superconductivity	320
	Literature	323
	Answers to Exercises	325
	Index	381