

Contents

Preface — ix

1 Maxwell's Equations — 1

- 1.1 Coulomb's and Gauss' Law — 2
- 1.2 Faraday's Law — 4
- 1.3 Ampere-Maxwell Law — 5
- 1.4 Electromagnetic Waves in Free Space — 6
- 1.5 Electromagnetic Waves in Matter — 9
- 1.6 Snell's Law and Evanescent Waves — 13
- 1.7 Group and Phase Velocity — 17
- 1.8 Waveguides — 19

2 Electromagnetic Properties of Metals — 25

- 2.1 Origin of Permittivity — 25
- 2.2 Permittivity and Conductivity of Conductors — 27
- 2.3 Electromagnetic Waves in a Conductor — 29

3 Plasma Kinetic Theory — 33

- 3.1 Introduction — 33
- 3.2 Exact Solutions for Time-Independent Electric Fields — 35
- 3.3 Linear Response Theory (Plasma Waves) — 37
- 3.4 Ponderomotive Theory — 39
- 3.5 $\vec{E} \times \vec{B}$ Drift — 43

4 Plasma Fluid Theory — 45

- 4.1 Introduction — 45
- 4.2 Derivation of the Fluid Equations — 45
- 4.3 Electrostatic Wave — 48
- 4.4 Plasma Conductivity and Permittivity — 50
- 4.5 Electromagnetic Waves — 51

5 Surface Plasmon Polaritons (SPP) — 55

- 5.1 SPP on Single Interface — 56
 - 5.1.1 TE Mode of SPP — 57
 - 5.1.2 TM Mode of SPP — 58

5.2	SPP on Multilayer Systems —	60
5.3	Excitation of SPP —	62
5.4	Localized Surface Plasmon Resonance (LSPR) —	65
5.5	Applications of Surface Plasmons —	69
6	Spoof Surface Plasmons (SSP) —	71
6.1	SSP at Low Frequencies —	71
6.2	SSP at High Frequencies —	73
6.3	Self-collimation in SSP —	77
7	Advanced Topics in Plasmonics —	83
7.1	Negative Index Metamaterials (NIMs) —	83
7.2	Surface-Enhanced Raman Scattering (SERS) —	88
7.3	Particle Traps —	90
8	Mathematical Foundations —	99
8.1	Scalars and Vectors —	99
8.1.1	Coordinate Systems: Cartesian, Cylindrical and Spherical —	99
8.1.2	Gradient of a Scalar —	104
8.1.3	Divergence and Curl of a Vector —	105
8.1.4	Scalar and Vector Integration —	107
8.1.5	Vector Identities —	110
8.1.6	Scalar and Vector Potential —	111
8.2	Lorentz Transformations and Special Relativity —	113
8.3	LTI Systems and Green's Function —	117
8.4	Fourier Transform —	121
8.5	Linear Stability Analysis of ODEs —	125
8.6	Hamiltonian Formulation of Charged Particle Dynamics —	134
9	Numerical Methods for Electromagnetics —	139
9.1	Laplace Equation —	139
9.2	Runge-Kutta Method —	141
9.3	Wave Equation: FDTD Method —	144
9.4	FDTD Dispersion Relation —	146
9.5	Dispersive Materials —	148
Appendix: Legendre Polynomials —		153
Bibliography —		155
Index —		157