Contents

1 Foundation of Electromagnetic Theory 1
1.1 Introduction 1
1.2 Vector Analysis 2
1.2.1 Vector Algebra 2
1.2.2 Vector Gradient 7
1.2.3 Vector Integration 10
1.2.4 Vector Divergence 12
1.2.5 Vector Curl 13
1.2.6 Vector Differential Operator 14
1.3 Further Developments 15
1.4 Electrostatics 18
1.4.1 The Coulomb's Law 19
1.4.2 The Electric Field 21
1.4.3 The Gauss's Law 23
1.5 Solution of Electrostatic Problems 25
1.5.1 Poisson's Equation 25
1.5.2 Laplace's Equation 27
1.6 Electrostatic Energy 27
1.6.1 Potential Energy of a Group of Point Charges 27
1.6.2 Electrostatic Energy of a Charge Distribution 28
1.6.3 Forces and Torques 30
1.7 Maxwell's Equations 34
1.8 Debye Length 35
1.9 Physics of Plasmas 37
1.10 Fluid Description of Plasma 38
1.11 MHD 41
1.12 Plasma Stability 43
1.13 Kink Stability 46
References 48

2 Principles of Plasma Physics 49
2.1 Introduction 49
2.2 Barrier Penetration 53
2.3 Calculation of Coulomb Barrier 54
2.4 Thermonuclear Fusion Reactions 59
2.5 Rates of Thermonuclear Reactions 62
2.6 Thermonuclear Fusion Reactions 65
2.7 Critical Ignition Temperature for Fusion 75
2.8 Controlled Thermonuclear Ideal Ignition Temperature 78
2.9 Bremsstrahlung Radiation 81
2.10 Bremsstrahlung Plasma Radiation Losses 86
2.11 Bremsstrahlung Emission Rate 88
2.12 Additional Radiation Losses 93
2.13 Inverse Bremsstrahlung in Controlled Thermonuclear ICF and MCF 95
References 101

3 Confinement Systems for Controlled Thermonuclear Fusion 103
3.1 Introduction 103
3.2 Magnetic Confinement Fusion 105
3.3 Summary of Guiding Center Drift 127
3.4 Motion of Plasma Particles in a Magnetic Field 128
3.5 Stabilization of the Pinched Discharge 130
3.6 Linear Pinched Discharge 137
3.7 Magnetic Confinement Fusion Reactors 137
3.7.1 The Tokamak 138
3.7.2 The Reversed-Field Pinch 148
3.7.3 The Stellarator 166
3.7.4 The Field-Reversed Configuration 174
3.7.5 The Levitated Dipole 176
References 180

Index 183