

Contents

Preface	iii
Preface to the Dover Edition	v
1 Introduction	1
1.1 The Science of Plasma Confinement	1
1.2 Goals and Synopsis	2
1.3 Confinement Demands of Controlled Fusion	3
1.4 Magnetized Plasma Confinement	7
1.5 Character of Toroidal Confinement	11
1.6 Understanding Confinement	18
2 Review of Fundamentals	21
2.1 Tensor Calculus	21
2.2 Lagrangian and Hamiltonian mechanics	29
2.3 Maxwell-Lorentz equations	32
2.4 Charged Particle Motion	36
3 Confined Plasma Equilibrium	49
3.1 Flux Surfaces	50
3.2 Magnetic Flux Coordinates	57
3.3 Applications of Flux Coordinates	63
3.4 Special Cases of Flux Coordinates	67
3.5 Scalar Pressure Equilibrium	73
3.6 Explicit Force Balance	78
3.7 Ampère's Law	82
3.8 Tensor Pressure Equilibrium*	86
3.9 Magnetic Field	90
3.10 Plasma Current	90
3.11 Equilibrium Electric Field	96

3.12 Large Aspect Ratio Approximation	99
3.13 Summary	107
4 Kinetic Description	117
4.1 General Kinetic Equation	117
4.2 Drift-kinetic Equation	126
4.3 Gyrokinetic Equation*	136
4.4 Guiding-center Phase Space	149
4.5 Application: Flow of a Magnetized Plasma	159
4.6 Summary	168
5 Coulomb Collisions	173
5.1 General Collision Operator	173
5.2 Coulomb Operator	179
5.3 Application: The Equilibrium Distribution	193
5.4 Summary	204
6 Fluid Description	209
6.1 Moments of Distribution Function	209
6.2 Moments of Kinetic Equation	212
6.3 Small Gyroradius Ordering	217
6.4 MHD Closure	230
6.5 Generalization of MHD	238
6.6 Application of the Drift Model: Drift Waves	249
6.7 Summary	257
7 Stability of Confined Plasmas	263
7.1 General Stability Considerations	263
7.2 Ideal MHD Waves	268
7.3 Shear-Alfvén Law	269
7.4 Flute Reduction	275
7.5 Cylindrical Reduced MHD	284
7.6 Ideal MHD Stability*	297
7.7 Asymptotic Matching	304
7.8 Boundary Layer Theory	307
7.9 Kinetic Effects*	317
7.10 Ballooning Representation	325
7.11 Ideal Stability	330
7.12 Model Equation*	335
7.13 Non-Ideal Stability*	342

7.14	Summary	342
8	Collisional Transport	349
8.1	Classical Perpendicular Transport	349
8.2	Fluid Evolution in a Torus	356
8.3	Axisymmetric Geometry	362
8.4	Entropy Production*	368
8.5	Tokamak Transport: Basic Features	373
8.6	Tokamak Transport: Analysis and Results*	383
8.7	Summary	402
9	Nonlinear Processes	409
9.1	Magnetic Islands	409
9.2	Coherent Nonlinear Islands*	417
9.3	Multiple Helicity Fields	421
9.4	Anomalous Particle Transport	427
9.5	Ambipolarity and Rotation*	430
9.6	Summary	434
A	Useful Formulae	437