TABLE OF CONTENTS

PREFACE v

I. INTRODUCTION 1

II. DERIVATION OF THE MAGNETOHYDRODYNAMIC EQUATIONS . . 8

1. The equations of motion for a conducting fluid . . . 8
2. The magnetohydrodynamic equations 11
3. Additional simplifications 14

III. DISCUSSION OF THE MHD EQUATIONS 17

1. Structure of the equations 17
2. Balance equations 18
3. Magnetic pressure 20
4. Motion of the magnetic field 21

IV. STATIC SOLUTIONS OF THE MHD EQUATIONS 28

1. The equations for the static case 28
2. Incompressible fluid 29
3. The pinched discharge 31
4. Static solution for compressible fluid with $\boldsymbol{g} \neq 0$ . . 35

V. STATIONARY SOLUTIONS 39

1. The equations for the stationary case 39
2. Force-free fields 40
3. Planar flow of a conducting viscous fluid 45
4. Terrestrial magnetism 49

VI. WAVES IN MAGNETOHYDRODYNAMICS 54

1. MHD waves in an incompressible plasma 54
2. MHD waves in the direction of $\boldsymbol{H}^0$ (Alfvén waves) . . 57
3. Compressible plasma: the linearized equations . . . 60
4. Solution of the eigenvalue problem (6) 62
5. The remaining modes 64

VII. INSTABILITY IN MAGNETOHYDRODYNAMICS 66
1. Instabilities in classical mechanics 67
2. Lagrange formulation of the MHD equations . . . 69
3. Equations of motion for neighboring solutions . . . 73
4. Applications 76
VIII. STATISTICAL MECHANICS OF AN IONIZED GAS IN EQUILIBRIUM . 82
1. Debye shielding 82
2. Statistical mechanics of a mixture of ionized gases . . 86
3. Statistical mechanics of the electron gas 87
4. Density fluctuations in the electron gas 94
5. Field fluctuations in the electron gas 95
6. Alternative calculation of the free energy of the electron gas 97
IX. TWO-COMPONENT THEORY 101
1. The equations of two-component theory 101
2. Plasma waves in a cold plasma 105
3. Discussion of the transverse waves in a cold plasma . . 111
4. Plasma waves in a hot plasma 113
5. Alternative derivation of waves in a cold plasma . . 117
X. KINETIC FOUNDATIONS OF THE MANY-COMPONENT THEORY . . 119
1. Kinetic equations for the many-component plasma . . 119
2. Conservation equations for macroscopic quantities . . 121
3. The equations of many-component theory 123
4. Discussion of the two-component theory 125
XI. THE VLASOV THEORY 130
1. The Vlasov equation 130
2. Properties of the Vlasov equation 131
3. Vlasov equation for longitudinal waves 134
XII. CORRECT TREATMENT OF LONGITUDINAL PLASMA WAVES . . 139
1. Mathematical preliminaries 139
2. Exact stationary solutions 142
3. The initial value problem 145
4. The evolution of the density 150
5. Comments on the irreversible behavior of the density . 153
XIII. TRANSVERSE WAVES IN THE VLASOV THEORY 159
1. The equations for transverse waves 159
2. Stationary solutions of equation (4) 161
3. The initial value problem for equation (4) 163
4. The initial value problem for the linearized Vlasov equation 165

5. Cut-off at the velocity of light 166
6. The relativistic Vlasov equation 170
7. Dispersion law and index of refraction. 172
XIV. ANISOTROPY AND EXTERNAL MAGNETIC FIELD. 178
1. The linearized Vlasov equation with external field . . 179
2. Isotropic equilibrium distribution in external field . . 180
3. Anisotropic equilibrium distribution, no external field . 182
4. Anisotropic equilibrium distribution with external field . 184
XV. COLLISIONS 188
1. The Landau equation 189
2. Discussion of the Landau equation 195
3. Kinetic theory 200
4. The method of Bogolyubov 204
AUTHOR INDEX 209
SUBJECT INDEX 212