

CONTENTS

PREFACE	V
INTRODUCTION	1
CHAPTER 1: MOTION OF ELECTRONS AND IONS IN ELECTRIC AND MAGNETIC FIELDS	
Introduction.	6
1.1. Motion in an electrostatic field	6
1.2. Motion in a magnetostatic field	7
1.2.1. Motion of charged particles in a toroidal magnetic field	
1.2.2. Motion of charged particles in the field of a magnetic lens	
1.2.3. Motion of charged particles in a helical magnetic field	
1.3. Motion of charged particles in crossed electric and mag- netic fields	21
1.3.1. Superimposed toroidal magnetic field and betatron magnetic field	
1.3.2. Electric vortex field and magnetic lens field	
1.4. The movement of a charged particle in the field of an electromagnetic wave.	32
1.5. Motion in crossed r.f. electric field and a magnetostatic field	34
1.6. Radiation from accelerated charges	38
1.6.1. The bremsstrahlung	
1.6.2. Cyclotron (betatron, synchrotron) radiation	
1.6.3. Čerenkov radiation	
List of symbols used in chapter 1	53
CHAPTER 2: FLUID DESCRIPTION OF PLASMA	
Introduction.	54
2.1. Stationary distributions	58
2.2. The Boltzmann equation	59

2.2.1. Non-relativistic ensemble	
2.2.2. Relativistic ensemble	
2.3. Integrals of Boltzmann equations over the velocity space	66
2.3.1. Non-relativistic case	
2.3.2. Relativistic case	
2.4. Fluid equations	73
References	77
List of symbols used in chapter 2	77
CHAPTER 3: EQUILIBRIUM CONFIGURATIONS	
Introduction.	78
3.1. Confinement by magnetic fields generated by currents in the plasma	80
3.1.1. Non-relativistic streams	
3.1.2. Relativistic streams	
3.2. Plasma in an external magnetic field	89
3.3. Plasma equilibrium in external and self-fields	96
3.4. Force-free magnetic fields.	98
References	100
List of symbols used in chapter 3	100
CHAPTER 4: WAVES AND INSTABILITIES IN PLASMA	
Introduction.	101
4.1. Electron oscillations in plasma	102
4.1.1. The longitudinal oscillations	
4.1.2. The transversal oscillations	
4.1.3. Hybrid transversal and longitudinal waves	
4.1.4. Effect of random velocities on the dispersion relations (Landau damping)	
4.1.5. Reflection of electromagnetic waves by plasma	
4.1.6. Electron waves on a plasma cylinder	
4.2. Positive ion oscillations.	118
4.2.1. Electrostatic ion oscillations	
4.2.2. Hydromagnetic oscillations in a stationary plasma — infinite plasma — waves on a plasma cylinder	
4.2.3. Hydromagnetic oscillations in plasma streams	

4.3. Growing waves and instabilities	131
4.3.1. Conversion of kinetic energy of particle streams into the energy of longitudinal plasma oscillations	
4.3.2. Conversion of potential energy into kinetic energy of plasma — Energy principle for hydromagnetic instabilities	
4.3.3. Hydrodynamic instability	
References	146
List of symbols used in chapter 4	147

CHAPTER 5: SHOCK WAVES IN PLASMA

Introduction.	148
5.1. Shock waves in a magnetic field — free plasma.	150
5.2. Shocks in a gyrotropic plasma.	152
5.3. Shocks in vacuum	153
5.4. Plasmoids	157
References	160
List of symbols used in chapter 5	160

CHAPTER 6: COLLISION AND RELAXATION PROCESSES

Introduction.	161
6.1. Dynamics of a collision of two charged particles	161
6.2. Fokker-Planck equation	165
6.2.1. Conduction of electricity in plasma — Conduction of electricity in a gyrotropic plasma	
6.3. Diffusion in configuration space	177
6.3.1. Flux of particles	
6.3.2. Conduction of heat and electricity	
6.3.3. Diffusion of momentum. Viscosity	
References	186
List of symbols used in chapter 6	186

APPLICATIONS

CHAPTER 7: RESEARCH ON CONTROLLED FUSION

Introduction 189

7.1. Sources of nuclear energy 189

 7.1.1. Elementary nuclear concepts

 7.1.2. Binding energy

 7.1.3. Nuclear fusion

 7.1.4. Fission and fusion reactions as sources of energy

 7.1.5. Uncontrolled fusion reactions

 7.1.6. Controlled fusion reactions

7.2. Confinement 210

 7.2.1. External fields — Toroidal confinement, mirror confinement, radiofrequency confinement

 7.2.2. Self-field confinement

 7.2.3. Confinement by the magnetic field of a relativistic electron stream

7.3. Heating and energy balance. 226

 7.3.1. Dynamic pinch

 7.3.2. Joule's heating

 7.3.3. Losses

7.4. Approaches to the problem of controlled fusion . . . 232

References. 234

List of symbols used in chapter 7 234

CHAPTER 8: OTHER APPLICATIONS

8.1. Generation of h.f. electromagnetic waves 236

8.2. Direct conversion of chemical energy into electrical energy 240

8.3. Applications to particle accelerators 246

 8.3.1. Injection into betatrons

 8.3.2. Guiding fields in circular accelerators

 8.3.3. Acceleration mechanisms

8.4. Rocket propulsion 257

8.5. Energy storage. 260

References. 262

List of symbols used in chapter 8 263

LITERATURE 264

 Books 264

 Publications in scientific journals related to the individual chapters 264

NAME AND SUBJECT INDEX 275