

Contents

<i>About the Author</i>	<i>xiii</i>
<i>Foreword</i>	<i>xiv</i>
<i>Acknowledgements</i>	<i>xvi</i>
<i>Notation</i>	<i>xvii</i>

I. General Principles

§1. Introduction	1
§2. Kinematics	2
§3. Deformation	3
§4. Transformation of a volume element	4
§5. Rate of change of a volume element	5
§6. The hydrodynamics derivative	7
§7. Reynolds' transport theorem	8
§8. Hamilton's principle	9

Selected Topics

The velocity field	11
Jacobian variation	15
Euler's relation	15
Hamilton's principle in fluid dynamics	16
<i>References</i>	18

II. Mass Density

§9. The continuity equation	19
§10. The small deformation strain tensor as a fundamental metric tensor	21
§11. The scalar equation for the mass density	25
§12. The dilute gas	28

Selected Topics

The continuity and motion equations	31
Bossinesq's approaches	33
The mass balance equation	34

Demonstration of a few formulae	36
The molecular chaos hypothesis	37
<i>References</i>	38

III. Analytical Mechanics

§13. Analytical treatment of mechanics	39
§14. The Hamilton-Type variational principle	40
§15. Temporary variations	41
§16. The field equation for the mass density	44

Selected Topics

The Hamilton-Type least action principle	47
Noether's theorem	49
Description of classical fields	50
The calculus of variations	50
The fundamental processes of the calculus of variations	51
The commutative properties of the δ -process	53
Temporary variation of the action	55
The variational method	56
Green's theorem	57
The mass balance	59
<i>References</i>	60

IV. Ideal Fluids

§17. Field functions for an ideal fluid	61
§18. Hamilton-Type variational principle and field differential equations	62
§19. Generalized energy balance equation	65
§20. Euler's motion equation	68
§21. Energy conservation law	69

Selected Topics

Euler-Lagrange's equations	75
Isentropic flux	77
Equivalence between the isentropic flux and the energy balance equation	78
Bernoulli's equation	79
Proper time	81
The action integral and the lagrangian for a free particle	83
The relativistic form of lagrangian density	85

The geometrical form of relativistic lagrangian density	87
The mass-energy relation	88
Momentum and energy	91
Momentum and energy in fluid dynamics	92
<i>References</i>	94

V. Potential Flow

§22. Wave equation	95
§23. Field differential equations	98
§24. Potential energy density	100
§25. The lagrangian density and the specific lagrangian	103
§26. The linearised continuity equation	106
§27. The energy conservation law of sound waves	110
§28. Pressure and density variations	111
§29. Deformation waves	114
§30. Pressure waves	116

Selected Topics

The sound velocity	117
Plane waves	119
The wave equation in terms of the change in the density	123
Variations in pressure and density	124
Geometrical acoustics	125
<i>References</i>	126

VI. Viscous Fluids

§31. Dissipative proceses in a viscous fluid	127
§32. The thermodynamics of deformation	128
§33. Field differential equations	132
§34. Generalized energy balance equation	136
§35. Cauchy's and Navier-Stokes' equations	139
§36. Energy conservation law	141
§37. The general equation of heat transfer	143

Selected Topics

The concept of viscosity	145
Viscosity stress tensor	146
The entropy	148
The thermodynamic entities in a real fluid	152

Fourier's equation	154
References	155

VII. Free Convection

§38. The start up mechanism of free convection	157
§39. The conditions so that the mechanical equilibrium be unstable	158
§40. The velocity field	161
§41. The general equation of heat transfer	165
§42. Polytropic atmosphere	169
§43. Some numerical results	172

Selected Topics

The atmosphere	173
The mechanical equilibrium in the atmosphere	176
Air density changes with temperature and humidity	178
The control of atmospheric pollution	180
Wind generation	182
References	184

VIII. Magnetohydrodynamics

§44. Field equations in a mobile conducting continuous medium	185
§45. The change in the generalized specific internal energy	188
§46. Momentum balance equation	190
§47. Generalized energy balance equation	192
§48. The equation of motion	194
§49. Energy conservation law	196
§50. General equation of heat transfer	197
§51. Thermal equation of state	199

Selected Topics

Magnetohydrodynamics and plasma physics	201
Generalized Bernoulli's equation	203
References	206

IX. Potential Flow in a Magnetic Field

§52. The equation of motion	207
-----------------------------	-----

§53.	Field differential equations	211
§54.	The lagrangian functions	211
§55.	The energy conservation law	215

Selected Topics

The drift of the lines of force	216
Magnetic difusión	219
The method of separation of variables	220
<i>References</i>	222

X. Magnetohydrodynamic Waves

§56.	Alfven's waves	223
§57.	Alfven's wave equation	225
§58.	Kinetic and potential energy densities	227
§59.	Field differential equations	231
§60.	Energy conservation law	234

Selected Topics

Transversal displacements	235
The pressure and the velocity of sound	236
<i>References</i>	238

XI. The Sunspots

§61.	The problem of the sunspots	239
§62.	Dynamic equilibrium between regulatory and startup mechanisms	241
§63.	The velocity of the fluid in the sunspots	245
§64.	General equation of heat transfer	251
§65.	Magnetic field of the sunspots	252
§66.	Persistency of the sunspots	256
§67.	Origin, permanency, disappearance, and properties of the sunspots	257

Selected Topics

The spontaneous magnetic field produced by a turbulent motion	261
Diffusion of magnetic field into a plasma	263
The thermal equation of the sunspots	265
<i>References</i>	266

XII. The Hamilton Equations of Motion

§68.	Legendre's transformation	267
§69.	Hamilton's canonical equations	270
§70.	The energy balance equation	275
§71.	The field of the specific enthalpy	277
§72.	Nature of interactions in fluid dynamics	281

Selected Topics

	The specific hamiltonian	282
	The canonical integral	283
	Energy theorem	286
	The variation of generalized momentum	288
	The homogeneous form of the canonical equations	290
	Cyclic variables	291
	<i>References</i>	292

XIII. Thermodynamics

§73.	The system of a single phase	293
§74.	Total internal enegy	294
§75.	The change in the total internal energy	297
§76.	The second law of thermodynamics	299
§77.	Entropy and quantity of heat	302
§78.	Temperature	304
§79.	Hamilton's formulation	308
§80.	Generalized momenta and the hamiltonian density	309
§81.	Helmholtz free energy	310
§82.	The heat function	312
§83.	Mechanical work and quantity of heat	313
§84.	The thermodynamic identity	314
§85.	Gibbs' free energy	316
§86.	Maxwell relations	318

Selected Topics

	Adiabatic proceses and mean values	321
	Entropy and temperature	322
	Temperature and energy	325
	Pressure	326
	The Helmholtz free energy as a mechanical potential	328
	The generalized thermodynamic potentials	329

<i>References</i>	332
-------------------	-----

XIV. The Magnetic Field in the Stability of the Stars

§87.	The self-generated magnetic field	333
§88.	The internal structure and the stability of a gaseous star	335
§89.	The magnetic field on the surface of a star	339
§90.	The mass-luminosity relation and the coefficient of opacity	341
§91.	Luminosity and opacity	343
§92.	The central temperature	344
§93.	The problem of variable stars of the cepheid type	345
§94.	The magnetic field in the inner part of a gaseous star	349

Selected Topics

	The scale of stellar magnitudes	360
	Luminosity and stellar radius	361
	Stellar distances	363
	Time scale of stellar evolution	365
	A simple model to estimate p_c, T_c , and H_c	368
	Polytropic gas sphere	371
	Gaseous stars	374
	A numerical equation for β	375
	The magnetic field in homologous inner points	378
	The mass and the luminosity	380
	The effective temperature and the absolute magnitude	381
	The absolute magnitude	389
	The magnetic field self-generated by gaseous stars	392
	The self-generated geomagnetic field	398
	<i>References</i>	402

<i>Index</i>	403
--------------	-----

The Hamilton-Type Principle in Fluid Dynamics
Fundamentals and Applications to
Magnetohydrodynamics, Thermodynamics, and
Astrophysics

Fierros Palacios, A.

2006, XXV, 404 p., Softcover

ISBN: 978-3-211-24964-2