
Contents

Preface	xi
List of Symbols	xv
Chapter 1. Objections and Rebuttals of Current Laws	1
1.1. Discussion on the general concepts	1
1.1.1. Choosing a three-dimensional space	1
1.1.2. Galileo's law of free-falling bodies	2
1.1.3. Uniform rotation, a Galilean motion	2
1.1.4. Galileo and Lorentz invariants	5
1.1.5. Distinction between velocity and celerity	6
1.1.6. Space-time or space and time?	7
1.2. Objections to the equations of classical mechanics	8
1.2.1. Equations of mechanics	8
1.2.2. Divergence and curl operators	10
1.2.3. The Stokes relation, an erroneous assumption	11
1.2.4. Non-relativistic equations	12
Chapter 2. A Different View of Space and Time	15
2.1. Maxwell's local frame of reference	15
2.2. Length and time	17
2.3. The local notion of vector in an n -dimensional space	18
2.3.1. The example of the gravity vector	20
2.3.2. Vector precession	21
2.4. Acceleration, velocity and celerity	22
2.4.1. Velocity limits	23
2.4.2. Adding velocities	25
2.5. Galileo and Lorentz transformations	26

2.6. The genesis of a unified law	27
2.6.1. The principle of parsimony or Ockham's razor	27
2.6.2. Extension of Galileo's principle of inertia to rotation	29
2.6.3. Interpretation of the WEP	32
2.6.4. Concept of physical homology	36
2.7. Mass or energy	36
2.7.1. Energy per unit mass	37
2.8. The quantities of a unified physics	38
2.8.1. Historical background	38
2.8.2. From the international system to the unification of units	39
2.8.3. Unified variables	39
2.8.4. Unified potentials	40
2.8.5. Curvature of physics potentials	43
2.9. A one-dimensional model of space and time	45
2.9.1. Representation of space in the equations of physics	45
Chapter 3. Unified Law of Motion	49
3.1. Dynamics of accelerated motions	49
3.2. Dynamics of uniform expansion and rotational motion	50
3.3. Kinematics of motion in discrete mechanics	54
3.3.1. Non-accelerated motion	54
3.3.2. Accelerated motion	56
3.4. Laws of conservation of compressive and rotational energy	57
3.5. Total energy conservation law	59
3.6. Principle of inertia	62
3.6.1. The nonlinear terms of inertia	62
3.6.2. Inertia as the curvature of the Bernoulli potential	63
3.6.3. Inertia of two superimposed motions	67
3.6.4. Example of uniform rotational motion	67
3.7. Helmholtz–Hodge decomposition	69
3.7.1. HHD of acceleration	69
3.7.2. HHD of velocity	71
3.7.3. Orthogonality of the decomposition	72
3.8. Properties of the law of motion	74
3.8.1. A relativistic law	74
3.8.2. A limitless local law	75
3.8.3. Dissipation of compression and shear energies	76
3.9. Potential couplings and interaction	77
3.9.1. Properties of media	77
3.9.2. Unified law of motion	79
3.9.3. Law of motion and source potentials	80

Chapter 4. Consequences of the Law of Motion	83
4.1. Weak equivalence principle revisited	83
4.1.1. The example of a falling heterogeneous body	83
4.1.2. Violation of the WEP	85
4.2. Velocity limit	89
4.2.1. Uniformly accelerated translational motion	89
4.2.2. Uniformly accelerated rotational motion	94
4.3. Advection	95
4.4. Local primal and dual forms of Bernoulli's law	97
4.4.1. An equation of motion for incompressible flows of viscous fluid	99
4.5. Invariances and Noether's theorem	101
4.6. Absence of constitutive laws	105
 Chapter 5. Fluid Mechanics	 107
5.1. Inertia, a concept at the heart of mechanics	107
5.1.1. Physical meaning of $\mathcal{L} = \mathbf{V} \times \nabla \times \mathbf{V}$	109
5.1.2. Example of a three-dimensional space vector	111
5.1.3. Intrinsic property $\mathbf{v} \perp \nabla \times \mathbf{v}$	112
5.1.4. Application of the NS equations to inertia	116
5.1.5. The consequences	118
5.1.6. A steady solution	118
5.2. Incompressible fluid mechanics	120
5.2.1. A unified equation of fluid motion	121
5.2.2. Poiseuille flow	123
5.2.3. Taylor–Green vortex	125
5.2.4. Role of vortex stretching on a Taylor–Green vortex	130
5.3. Two-phase flows	133
5.3.1. Modeling the capillary acceleration	133
5.3.2. Geometric curvature	135
5.3.3. Classical estimates of normals and curvatures	136
5.3.4. Curvature in DM	138
5.3.5. Surface energy	141
5.3.6. An anisotropic intrinsic superficial tension	142
5.3.7. An equation of motion based on capillary acceleration	144
5.3.8. Capillary rise between two planar surfaces	146
5.4. Compressible flows	152
5.4.1. Analysis of redundancies in Euler's equations	152
5.4.2. Proposition for an alternative to Euler's equations	155
5.4.3. Rankine–Hugoniot conditions	158
5.4.4. Surface and shock discontinuities	159
5.4.5. Some elementary test cases	161
5.4.6. Propagation of a surface discontinuity	161

Chapter 6. Fluid–Structure Interactions and Porous Media	175
6.1. Equation of motion for a solid	176
6.2. Connection conditions	179
6.3. Some examples	182
6.3.1. Fluid–solid monolithic interaction on a simple example	182
6.3.2. Periodic shear in a fluid–solid layer	184
6.4. Other constitutive laws	187
6.4.1. Compression-related properties	187
6.4.2. Non-deformable solid	188
6.4.3. Viscoelastic model	189
6.4.4. Threshold fluid	190
6.5. Porous media	190
6.5.1. Physical description of flows in porous media	190
6.5.2. Discrete approach to flows in porous media	192
6.5.3. Darcy’s law	195
6.5.4. An examination of media anisotropy	198
6.5.5. Darcy–Forchheimer’s law	198
6.5.6. Flow in a variable cross-section channel	201
Chapter 7. Heat Transfer	203
7.1. Introduction	203
7.2. Analysis of the heat transfer equations	204
7.3. An alternative law of heat propagation	208
7.3.1. Maxwell’s local frame of reference	208
7.3.2. Modeling radiative transfer	210
7.3.3. Modeling diffusion transfer	213
7.4. A law of discrete transfer	215
7.4.1. Equivalence of discrete distributions	215
7.4.2. A unified law of motion	217
7.4.3. Advection	219
7.4.4. Anisotropy and polarization	220
7.4.5. Phase change	222
7.4.6. A relativistic equation	224
7.4.7. A reduction in the number of variables	225
7.5. Test cases	226
7.5.1. Radiative transfer between two cylinders	226
7.5.2. Heat transfer by diffusion in conductive media	228
7.5.3. The Stefan problem for a melting-type phase change	230
7.5.4. Simulation of melting in discrete formulation	233
7.5.5. Condensation in an undercooled cavity	235
7.5.6. Condensation with imposed temperature	236
7.5.7. Condensation in an anisothermic system	237

Chapter 8. Electromagnetism	241
8.1. Introduction	241
8.2. A few remarks about Maxwell's equations	242
8.2.1. Maxwell's model	242
8.2.2. Maxwell's equations in terms of potentials	244
8.2.3. Non-existence of monopoles	245
8.3. An alternative law of propagation of electromagnetic waves	245
8.3.1. Maxwell's local frame of reference	246
8.3.2. Modeling currents	247
8.3.3. The discrete law of motion	253
8.3.4. Inertia and Lorentz acceleration	255
8.3.5. Conservation of charges	256
8.3.6. Equations in terms of potential	258
8.3.7. A relativistic equation	259
8.3.8. The potential existence of monopoles	260
8.3.9. A drastic reduction in the number of variables	262
8.3.10. Differences and convergences	263
8.4. Some examples	265
8.4.1. Magnetic field created by a wire of infinite length	265
8.4.2. Magnetic field around a permanent magnet	266
8.4.3. Induced currents in a cylindrical conductor	267
8.4.4. Electromagnet coil	270
8.4.5. An example of electromagnetic levitation	271
8.5. Propagation of light	275
8.5.1. Light propagation equation	275
8.5.2. Interference produced from two coherent point sources	276
8.5.3. Refraction of a polarized monochromatic wave	278
Chapter 9. Relativity, Gravitation	281
9.1. An alternative to the theory of relativity	281
9.1.1. Alternative relativistic equation	282
9.2. Wave–energy duality	283
9.3. Photon velocity	286
9.3.1. Photon energy in theory of relativity	286
9.3.2. Photon energy in discrete mechanics	288
9.4. Gravitation	291
9.4.1. Physical principles revisited	291
9.4.2. Universal law of the fall of bodies with or without mass	293
9.4.3. Creation of the energy of bodies	295
9.4.4. The mechanism of star accretion	298
9.5. Two typical examples	301
9.5.1. Gravitational acceleration as a source term	301
9.5.2. Gravitational lensing	301

9.6. Gravitational redshift	303
9.7. Quantification	309
9.7.1. Notion of spin	309
9.7.2. A potential unification	311
References	315
Index	327