

CONTENTS

Preface	v
Introduction	1
Chapter 1. History of the Development of Relativity Theory	3
Chapter 2. Physical and Conceptual Foundations of the Theory of Special Relativity	11
2.1. The Hypotheses of Newtonian Mechanics	11
2.2. The Galilean Relativity Principle and its Limits	13
2.3. The Einsteinian Principle of Relativity	19
2.4. The Lorentz Transformation	21
2.4.1. Deduction of the Lorentz Transformation from the Principle of Relativity	22
2.4.2. and from the Constancy of Velocity of Light	32
2.4.3. The Lorentz Transformation for Arbitrary Relative Velocities	33
2.4.4. Interval and the Principle of Invariance	34
2.5. Kinematical Consequences of the Lorentz Transformation	36
2.5.1. Contraction of Length	37
2.5.2. Dilation of Time	39
2.5.3. Non-Synchronism of Moving Clocks	43
2.5.4. Velocity Transformation	44
2.5.5. The Meter Stick Paradox	47
2.5.6. The Twin Paradox	50
2.5.7. Observation of Moving Objects	56

Chapter 3. Tensors	59
3.1. Scalars	60
3.2. Contravariant and Covariant Vector Components	62
3.3. Tensors of Higher Rank	65
3.3.1. Basic Properties of Tensors	65
3.3.2. Contractions	67
3.3.3. The Quotient Theorem	68
3.3.4. Relative Tensors	69
3.4. The Metric Tensor	71
3.5. Differentiation of Tensor Fields	75
3.6. Vectors in Euclidean Space	78
Chapter 4. Formulation of Relativity Theory in Minkowski Space	83
4.1. The Four-Dimensional Minkowski Space	83
4.2. Four-Vectors and ϵ -Tensors	87
4.3. The Full Lorentz Group	91
4.4. Geometrical Representation of the Lorentz Transformation	97
4.5. Proper Time, Velocity, Acceleration	102
Chapter 5. Relativistic Mechanics	105
5.1. Dynamical Equation for a Mass Point	105
5.2. Momentum, Energy, Mass	110
5.3. Interactions of Relativistic Particles via Fields	120
5.4. Energy-Momentum Conservation for Particle Processes	125
5.4.1. Decay	126
5.4.2. Creation	129
5.4.3. Scattering	131

5.5.	The Principle of Least Action; the Lagrangian	133
5.6.	Conservation Laws	137
Chapter 6.	Electrodynamics: An Example of a Relativistic Field Theory	143
6.1.	Wave Equations for the Electromagnetic Potentials	143
6.2.	Lagrangian for a Charge in an External Field	147
6.3.	The Electromagnetic Field Tensor and the Equations of Motion in an External Field	149
6.4.	Transformation of the Field Components and the Invariants of the Field	151
6.5.	Gauge Invariance	156
6.6.	Covariant Form of the Maxwell Equations	158
6.7.	The Doppler Effect	160
6.8.	Action Integral for the Electromagnetic Field and the Field Equations	164
6.9.	Noether's Theorem	168
6.10.	Energy-Momentum Tensor of the Electromagnetic Field	175
Chapter 7.	Relativistic Hydrodynamics	185
7.1.	The Nonrelativistic Equations	186
7.2.	Conservation of Particle Number	188
7.3.	Incoherent Matter	190
7.4.	The Ideal Fluid	192
Chapter 8.	Limits of Special Relativity	197
Appendix A:	Problems	205
Appendix B:	The Experimental Tests of Special Relativity	208
Index		211