

CONTENTS

	PAGE
INTRODUCTION	1

CHAPTER I

ELEMENTARY PRINCIPLES

SECTION

1. Indeterminateness of the space-time frame	8
2. The fundamental quadratic form	10
3. Measurement of intervals	11
4. Rectangular coordinates and time	13
5. The Lorentz transformation	17
6. The velocity of light	18
7. Timelike and spacelike intervals	22
8. Immediate consciousness of time	23
9. The "3 + 1 dimensional" world	25
10. The FitzGerald contraction	25
11. Simultaneity at different places	27
12. Momentum and Mass	29
13. Energy	32
14. Density and temperature	33
15. General transformations of coordinates	34
16. Fields of force	37
17. The Principle of Equivalence	39
18. Retrospect.	41

CHAPTER II

THE TENSOR CALCULUS

19. Contravariant and covariant vectors	43
20. The mathematical notion of a vector	44
21. The physical notion of a vector	47
22. The summation convention	50
23. Tensors	51
24. Inner multiplication and contraction. The quotient law	52
25. The fundamental tensors	55
26. Associated tensors	56
27. Christoffel's 3-index symbols	58
28. Equations of a geodesic	59
29. Covariant derivative of a vector	60
30. Covariant derivative of a tensor	62
31. Alternative discussion of the covariant derivative	65
32. Surface-elements and Stokes's theorem	66
33. Significance of covariant differentiation	68
34. The Riemann-Christoffel tensor	71
35. Miscellaneous formulæ	74

CHAPTER III

THE LAW OF GRAVITATION

SECTION	PAGE
36. The condition for flat space-time. Natural coordinates	76
37. Einstein's law of gravitation	81
38. The gravitational field of an isolated particle	82
39. Planetary orbits	85
40. The advance of perihelion	88
41. The deflection of light	90
42. Displacement of the Fraunhofer lines	91
43. Isotropic coordinates	93
44. Problem of two bodies—Motion of the moon	95
45. Solution for a particle in a curved world	100
46. Transition to continuous matter	101
47. Experiment and deductive theory	104

CHAPTER IV

RELATIVITY MECHANICS

48. The antisymmetrical tensor of the fourth rank	107
49. Element of volume. Tensor-density	109
50. The problem of the rotating disc	112
51. The divergence of a tensor	113
52. The four identities	115
53. The material energy-tensor	116
54. New derivation of Einstein's law of gravitation	119
55. The force	122
56. Dynamics of a particle	125
57. Equality of gravitational and inertial mass. Gravitational waves	128
58. Lagrangian form of the gravitational equations	131
59. Pseudo-energy-tensor of the gravitational field	134
60. Action	137
61. A property of invariants	140
62. Alternative energy-tensors	141
63. Gravitational flux from a particle	144
64. Retrospect	146

CHAPTER V

CURVATURE OF SPACE AND TIME

65. Curvature of a four-dimensional manifold	149
66. Interpretation of Einstein's law of gravitation	152
67. Cylindrical and spherical space-time	155
68. Elliptical space	157
69. Law of gravitation for curved space-time	159
70. Properties of de Sitter's spherical world	161
71. Properties of Einstein's cylindrical world	166
72. The problem of the homogeneous sphere	168

CHAPTER VI

ELECTRICITY

SECTION	PAGE
73. The electromagnetic equations	171
74. Electromagnetic waves	175
75. The Lorentz transformation of electromagnetic force	179
76. Mechanical effects of the electromagnetic field	180
77. The electromagnetic energy-tensor	182
78. The gravitational field of an electron	185
79. Electromagnetic action	187
80. Explanation of the mechanical force	189
81. Electromagnetic volume	193
82. Macroscopic equations	194

CHAPTER VII

WORLD GEOMETRY

PART I. WEYL'S THEORY

83. Natural geometry and world geometry	196
84. Non-integrability of length	198
85. Transformation of gauge-systems	200
86. Gauge-invariance	202
87. The generalised Riemann-Christoffel tensor	204
88. The in-invariants of a region	205
89. The natural gauge	206
90. Weyl's action-principle	209

PART II. GENERALISED THEORY

91. Parallel displacement	213
92. Displacement round an infinitesimal circuit	214
93. Introduction of a metric	216
94. Evaluation of the fundamental in-tensors	218
95. The natural gauge of the world	219
96. The principle of identification	222
97. The bifurcation of geometry and electrodynamics	223
98. General relation-structure	224
99. The tensor $*P_{\mu\nu\sigma}^{\epsilon}$	226
100. Dynamical consequences of the general properties of world-invariants	228
101. The generalised volume	232
102. Numerical values	235
103. Conclusion	237
SUPPLEMENTARY NOTES	241
BIBLIOGRAPHY	264
INDEX	267