

TABLE OF CONTENTS

Licensing

1: Geometric Theory of Spacetime

- 1.1: Time and Causality
- 1.2: Experimental Tests of the Nature of Time
- 1.3: Non-simultaneity and Maximum Speed of Cause and Effect
- 1.4: Ordered Geometry
- 1.5: The Equivalence Principle (Part 1)
- 1.6: The Equivalence Principle (Part 2)
- 1.E: Geometric Theory of Spacetime (Exercises)

2: Geometry of Flat Spacetime

- 2.1: Introduction to Geometry of Flat Spacetime
- 2.2: Affine Properties of Lorentz Geometry (Part 1)
- 2.3: Affine Properties of Lorentz Geometry (Part 2)
- 2.4: Relativistic Properties of Lorentz Geometry (Part 1)
- 2.5: Relativistic Properties of Lorentz Geometry (Part 2)
- 2.6: The Light Cone
- 2.7: Experimental Tests of Lorentz Geometry
- 2.8: Three Spatial Dimensions (Part 1)
- 2.9: Three Spatial Dimensions (Part 2)
- 2.E: Geometry of Flat Spacetime (Exercises)

3: Differential Geometry

- 3.1: Introduction to Differential Geometry
- 3.2: Tangent Vectors
- 3.3: Affine Notions and Parallel Transport
- 3.4: Models
- 3.5: Intrinsic Quantities
- 3.6: The Metric (Part 1)
- 3.7: The Metric (Part 2)
- 3.8: The Metric in General Relativity
- 3.9: Interpretation of Coordinate Independence
- 3.E: Differential Geometry (Exercises)

4: Tensors

- 4.1: Lorentz Scalars
- 4.2: Four-vectors (Part 1)
- 4.3: Four-vectors (Part 2)
- 4.4: The Tensor Transformation Laws
- 4.5: Experimental Tests
- 4.6: Conservation Laws
- 4.7: Things that Aren't Quite Tensors
- 4.E: Tensors (Exercises)

5: Curvature

- 5.1: Introduction to Curvature
- 5.2: Tidal Curvature Versus Curvature Caused by Local Sources
- 5.3: The Stress-energy Tensor
- 5.4: Curvature in Two Spacelike Dimensions
- 5.5: Curvature Tensors
- 5.6: Some Order-of-magnitude Estimates
- 5.7: The Covariant Derivative
- 5.8: The Geodesic Equation
- 5.9: Torsion
- 5.10: From Metric to Curvature
- 5.11: Manifolds (Part 1)
- 5.12: Manifolds (Part 2)
- 5.13: Units in General Relativity
- 5.E: Curvature (Exercises)

6: Vacuum Solutions

- 6.1: Event Horizons
- 6.2: The Schwarzschild Metric (Part 1)
- 6.3: The Schwarzschild Metric (Part 2)
- 6.4: Black Holes (Part 1)
- 6.5: Black Holes (Part 2)
- 6.6: Degenerate Solutions
- 6.E: Vacuum Solutions (Exercises)

7: Symmetries

- 7.1: Killing Vectors
- 7.2: Spherical Symmetry
- 7.3: Penrose Diagrams and Causality
- 7.4: Static and Stationary Spacetimes (Part 1)
- 7.5: Static and Stationary Spacetimes (Part 2)
- 7.6: The Uniform Gravitational Field Revisited
- 7.E: Symmetries (Exercises)

8: Sources

- 8.1: Sources in General Relativity (Part 1)
- 8.2: Sources in General Relativity (Part 2)
- 8.3: Cosmological Solutions (Part 1)
- 8.4: Cosmological Solutions (Part 2)
- 8.5: Cosmological Solutions (Part 3)
- 8.6: Sources in General Relativity (Part 3)
- 8.7: Cosmological Solutions (Part 4)
- 8.8: Mach's Principle Revisited
- 8.9: Historical Note - The Steady-state Model
- 8.E: Sources in General Relativity (Exercise)

9: Gravitational Waves

- 9.1: The Speed of Gravity
- 9.2: Gravitational Radiation (Part 1)
- 9.3: Gravitational Radiation (Part 2)

- [9.E: Gravitational Waves \(Exercises\)](#)

10: Appendices

- [10.1: Appendix A \(Part 1\)](#)
- [10.2: Appendix A \(Part 2\)](#)
- [10.3: Appendix A \(Part 3\)](#)
- [10.4: Appendix C](#)

[Index](#)

[Index](#)

[Glossary](#)

[Detailed Licensing](#)