

General Relativity

Introduction to General Relativity by Eduardo Martín-Martínez

1. Preliminaries 1: Index notation and Einstein's sum convention
2. Preliminaries 2: Tensors, Covariance and Contravariance
3. Brief historical context of Special relativity
4. Postulates of Special Relativity and Lorentz Transformations
5. Special Relativity: Proper time and non-inertial motion
6. Special Relativity: Lorentzian tensors and Minkowski metric
7. The Poincaré Group Part 1: The translations group
8. The Poincaré Group Part 2: The Lorentz Group
9. The Poincaré Group Part 3: Playing with the Lorentz group
10. Hamilton's Principle and Noether's theorem in Special Relativity
11. Free Particle Dynamics in Special Relativity
12. Collision problem examples in special relativity
13. Non-inertial frames in Special Relativity and Rindler coordinates
14. Differential geometry: Topological and Differentiable Manifolds
15. Differential geometry: Curves, functions and vectors
16. Differential geometry: One-forms and Tensors
17. Differential geometry: n-forms, Exterior Derivative & Integration
18. Differential geometry: Pull-back, Push-forward and Lie Derivative
19. Differential geometry: Affine connection & covariant derivative
20. Differential geometry: Parallel transport, Geodesics & Curvature
21. Differential geometry: Metric Manifolds & Levi-Civita connection
22. Differential geometry: Isometries, Killing vectors & DG exercises
23. The Postulates of General Relativity & Free Particle Dynamics

24. [Stress-Energy Tensor and Energy Conditions](#)
25. [Schwarzschild metric 1: Introduction and Static Observers](#)
26. [Schwarzschild metric 2: Relativistic Orbital Mechanics](#)
27. [An amusing problem: Newton vs Einstein to the other side of Earth](#)
28. [Schwarzschild Black Holes](#)
29. [Cosmology part 1: LFRW spacetime from the cosmological principle](#)
30. [Cosmology part 2: Friedmann equations and Dark Energy](#)

Mathematics of General Relativity by James Cook

1. [Course Overview](#)
2. [Spacetime or Timespace](#)
3. [Index Calculations, Summation, an Example from Vector Algebra](#)
4. [Lorentz Transformations and Euclidean Isometries](#)
5. [Newtonian Space and Minkowski Space](#)
6. [Tensor Calculations in Minkowski Space and More](#)
7. [4-Vectors and Physics in Special Relativity](#)
8. [Maxwell's Equations](#)
9. [Lagrangian Mechanics](#)
10. [Classical Field Theory](#)
11. (a) [Equivalence Principle Sketched](#)
 (b) [On Calculus on Manifolds, a Lightning Tour](#)
12. [Metric on Spacetime](#)
13. [Overview of Curvature and Einstein's Field Equations](#)
14. (a) [Covariant Derivatives and Curvature from Frankel](#)
 (b) [Covariant Derivatives and Curvature from Carroll](#)
15. [Variational Calculus and Geodesics](#)

16. [Einstein's Equations and a Word on Generalizations of GR](#)
17. [Schwarzschild Solution](#)
18. [Gravitational Waves](#)
19. [Cosmological Models](#)
20. (a) [Tetrad Method, Lorentzian frames](#)
(b) [Calculating Curvature via Tetrad Formalism, Future Reading](#)

June 5, 2025