

MAM3040W-3GR/NASSP GR– Course Outline

2nd Semester 2025

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Notes

- *The following is an optimistic layout of what we intend to cover this semester. If there are any changes, updated versions of this document will be uploaded on Amathuna.*
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▶ **Chapter 1:** The Special Theory of relativity

- 1.1 Pre-relativistic physics
- 1.2 The equations of electromagnetism
- 1.3 The principle of Special Relativity
- 1.4 Spacetime diagrams and the Lorentz transformations
- 1.5 The spacetime interval
- 1.6 Minkowski spacetime
- 1.7 Consequences of the Einstein postulates
- 1.8 Velocity composition law

▶ **Chapter 2:** Vectors in Special Relativity

- 2.1 Four-vectors
- 2.2 Four-velocity, momentum and acceleration
- 2.3 Relativistic dynamics

▶ **Chapter 3:** Tensors in Special Relativity

- 3.1 Metrics and forms
- 3.2 One-forms
- 3.3 More general tensors
- 3.4 General properties of tensors
- 3.5 Tensor derivatives and gradients

3.6 The energy-momentum tensor

3.7 The Electromagnetic tensor

► **Chapter 4:** Conceptual Basis of General Relativity

4.1 The gravitational redshift experiment

4.2 Non-existence of an inertial frame at rest on earth

4.3 Mass in Newtonian theory

4.4 The principle of equivalence

► **Chapters 5:** Curved spacetime and General Relativity

5.1 Manifolds, tangent spaces and local inertial frames

5.2 Covariant derivatives and Christoffel symbols

5.3 Calculating Christoffel symbols from the metric

5.4 Tensors in polar coordinates

5.5 Parallel transport and geodesics

5.6 The curvature tensor and geodesic deviation

5.7 The Bianchi identities; Ricci and Einstein tensors

► **Chapters 6:** Einstein's Field Equations

6.1 The non-vacuum field equations

6.2 The weak field approximation

6.3 The Schwarzschild Solution

6.4 Orbits in Schwarzschild spacetime