

## Physics 751 – General Relativity – Spring 2015

Class meetings: M, W, F at 11:30 – 12:20 in 227 La Tourette  
Prof. S. Martin 214 La Tourette (815) 753-6467 [spmartin@niu.edu](mailto:spmartin@niu.edu)  
Office hours: M, T, W, F 1:00 – 1:50 (or whenever you can find me)  
Class home page: <http://www.niu.edu/spmartin/phys751>

**Textbook:** *Spacetime and Geometry: An Introduction to General Relativity* by Sean M. Carroll. Pearson Addison-Wesley, 2004. ISBN-13: 978-0805387322

**Grading:** Based 100% on homework. Late penalty policy: 10% off for each day after the due date, for up to 5 days; 100% off for  $> 5$  days late. I prefer homeworks to be turned in at the end of class, but they are considered on time if received by 5:00 PM on the due date. You are encouraged to consult with each other on the homework. However, everything you turn in must be your own work. Do not turn in anything that you have copied, or anything that you do not truly understand. Grades will be assigned according to your numerical score as a percentage, with each homework set weighted equally. The low cutoff for each grade is as follows:

A	90%,	A–	87%,	B+	84%,	B	80%,
B–	75%,	C+	70%,	C	65%,	D	55%.

No C– or D+ or D– grade will be assigned. I reserve the right to amend the above grading scale to be more lenient, but it is guaranteed not be made more strict.

### Topics to be covered:

- Special relativity and flat spacetime
  - Space, time, and Lorentz transformations
  - Vectors, dual vectors, and tensors
  - Maxwell’s equations
  - Energy and momentum
- Manifolds
  - Equivalence principle
  - Gravity as geometry
  - Definition and properties of manifolds
  - Vectors, dual vectors, and tensors on manifolds
  - Metrics
  - Tensor densities and integration
  - Causality
- Curvature
  - Connections, Christoffel symbols, and covariant derivatives
  - Parallel transport and geodesics
  - Riemann curvature tensor
  - Ricci tensor, Ricci scalar, and Weyl tensor

- Symmetries, isometries, and Killing vectors
- Gravity in curved spacetime
  - The equivalence principle
  - Einstein’s equation
  - Einstein-Hilbert action
  - Cosmological constant
- Black hole solutions
  - Schwarzschild metric
  - Geodesics and experimental tests
  - Eddington-Finkelstein and Kruskal coordinates
  - Event horizons and conformal diagrams
  - Eternal and astrophysical black holes
  - Hawking radiation and black hole evaporation
  - Black holes with charge and/or angular momentum
- Cosmology
  - Isotropic and homogeneous universes
  - Robertson-Walker metrics
  - Open, closed and flat universes
  - deSitter and anti-deSitter spaces
  - The scale factor and the Friedmann equation
  - Redshift and distance measurements
  - Observed parameters of our universe
  - The flatness and horizon problems
  - Inflation
- Linearized gravity
  - Perturbations to the flat Minkowski metric
  - Gauge transformations and gauge choices
  - Newtonian fields
  - Gravitational waves

**Accessibility Statement:** Northern Illinois University is committed to providing an accessible educational environment in collaboration with the Disability Resource Center (DRC). Any student requiring an academic accommodation due to a disability should let his or her faculty member know as soon as possible. Students who need academic accommodations based on the impact of a disability will be encouraged to contact the DRC if they have not done so already. The DRC is located on the 4th floor of the Health Services Building, and can be reached at 815-753-1303 (V) or [drc@niu.edu](mailto:drc@niu.edu).