PHYS-UA 170
Spring, 2020

# General Relativity

Instructor: Andrew MacFadyen, am193@nyu.edu, room 1036, 726 Broadway

Class: Tuesdays & Thursdays 9:30-10:45, room 802, 726 Broadway

Office Hours: TBD

Grading: Problem Sets 50%, Midterm Exam 20%, Final Exam 30%

## Text book and supplemental reading:

**"Gravity; An Introduction to Einstein's General Relativity" by James B. Hartle (Addison Wesley, 2009) (main text)**

**"A First Course in General Relativity," 2nd edition by B. Schutz (Cambridge University Press, 2009) (recommended text, available online via ebrary)**

"Spacetime And Geometry: An Introduction To General Relativity" by Sean Carroll (Pearson, 2003) (recommended advanced text)

"Gravitation," by Misner, Thorne and Wheeler (Princeton University Press) (classic comprehensive text)

"Einstein Gravity in a Nutshell" by A. Zee (Princeton University Press, 2013)

"Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity" by Steven Weinberg (Wiley, 1972) (advanced text)

Black Holes and Time Warps; Einstein's Outrageous Legacy, K. Thorne (Norton, 1994) (excellent popular book)

# Course Outline (subject to change):

Special Relativity (2 weeks)
- Inertial Frames, Principle of Relativity, Lorentz Transformations
- Spacetime, Coordinates and Invariance
- Relativistic Kinematics and Dynamics
- Variational Principle for Free Particle Motion, Light Rays

Gravity as Geometry (2 weeks)
- Equivalence principle, Tests of Equality of Inertial and Gravitational Mass
- Clocks in a Gravitational Field, Applications to the GPS
- Local Inertial Frames, Light Cones, World Lines, Vectors
- Geodesics, Symmetries and Conservation Laws

Black Holes (3 weeks)
- Schwarzschild Geometry, Gravitational Redshift
- Particle Orbits: Precession of the Perihelion of Mercury
- Light Ray Orbits: Deflection and time Delay of Light (Gravitational Lensing)
- Solar System Tests of General Relativity
- Gravitational Collapse to a Black Hole
- Astrophysical Back Holes (X-ray binaries, Galaxies, Hawking Radiation)

Gravitational Waves (2 weeks)
- Linearized Gravitational Waves, Energy, Polarization
- Detecting Gravitational Waves, Interferometers

Cosmology (1 week)
- Homogeneous and Isotropic Spacetimes: Expansion of the Universe, Cosmological Redshift
- Matter, Radiation, Vacuum Energies: Evolution of FRW Models

Einstein Equations (3 weeks)
- Tensors, Covariant Derivatives
- Tidal Gravitational Forces, Riemann Curvature
- Energy Momentum Conservation
- Einstein Field Equations, Newtonian Limit
- Applications: Production of Weak Gravitational Waves, Quadrupole Formula, Gravitational Radiation from Binary Pulsars