Lectures: Tuesdays & Thursdays 9:30 AM – 10:45 AM; 726 Broadway, Room 1045

Recitations: Wednesdays 4:55 – 6:10 PM; 726 Broadway, Room 1045

Instructor: Prof. Anthony R. Pullen
Contact: ap177@nyu.edu, 212-998-7634
Office: 726 Broadway, Room 938
Office Hours: TBA

TA: Trey Jenson
Contact: tj796@nyu.edu
Office: 726 Broadway, Room 946
Office Hours: TBA

Course Website:
Located on NYU Brightspace

Course Description
General relativity is the physics theory that formalizes Einstein’s revelation that gravity is not a force in the Newtonian sense but is instead a manifestation of the 4-dimensional geometry of space-time being curved by massive bodies. This theory allows particle trajectories to obey the principle of relativity, in which all laws of physics are the same in all reference frames, inertial or not. General relativity has survived every test in the weak-field regime, and it is now currently being tested with black hole and gravitational wave dynamics. While general relativity is typically taught as a graduate course, many of the foundational concepts can be taught at the undergraduate level. This course seeks to accomplish this feat.

This course will develop the theory of general relativity using the tools of spacetime geometry and the principle of least action. We will cover the following topics:

- Special Relativity
- Gravity as Geometry
- Spherical Stars and Black Holes
- Gravitational Waves
- Cosmology
- Einstein’s Equations.

Prerequisite
- Dynamics (PHYS-UA-120)

See Prof. Pullen if you have not satisfied this prerequisite.
Required Textbook


Other References


Problem Sets

Problem sets will consist of material covered in the lectures. The problem sets will be posted on the course website on Tuesday and are due at 5:00 PM the following Tuesday. The completed problem set can either be handed to me at the lecture upon arrival, scanned and uploaded to Brightspace, or dropped in the marked box located in the mailroom for the Physics Department administrative offices on the 10th floor of 726 Broadway. DO NOT slide your problem set under my office door or the TA’s; they will not be accepted. **Problem set solutions must be handwritten.** Solution sets will be posted on the course website on the Wednesday after it is due. Graded problem sets will be returned the following Tuesday in lecture.

The lowest problem set grade is dropped from your final grade. A missed problem set can count as your lowest grade to be dropped.

Problem sets should be attempted without discussing them with other students or looking at solution sets. Example problems will be solved both in lecture and in recitations, but there is no substitute for finding the solution for a problem on your own without the steps given to you, in order to truly master the concepts. Only if a student is truly stuck should they discuss the problem with the instructor, the TA, or other students. However, students are always required to turn in their own independent write-ups of the problem solutions.

**Late Homework Policy:** Problem sets will not be accepted after 5:00 PM on Tuesday without a valid medical excuse.

Exams

Exams will be take-home tests. They will be open book and notes, but no internet. Exam solutions must be handwritten. You will sign a pledge to follow these rules.
**Missed Exam Policy:** A doctor’s note is required to make-up an exam. **Traveling is not a valid reason to miss an exam.**

**Midterm**
The midterm will cover chapters 1-9 of Hartle. You will have 24 hours to complete the exam starting on Thursday, March 10 at 9:30 AM. The exam will be available to pick up from the lecture room (Room 1045) between 9:30-9:45 AM and to download from Brightspace at 9:30 AM. The exam will be due on Friday, March 11 at 11 AM. You can submit them in person at my office (Room 938) or electronically on Brightspace.

**Final**
The final exam will cumulative, covering material distributed throughout the semester’s lectures. You will have 24 hours to complete the exam starting on Thursday, May 12 at 10:00 AM. The exam will be available to pick up from the lecture room (Room 1045) between 10:00-10:15 AM and to download from Brightspace at 10:00 AM. The exam will be due on Friday, May 13 at 11 AM. You can submit them in person at my office (Room 938) or electronically on Brightspace.

**Grading**
- Problem Sets (dropping lowest score) – 50%
- Midterm – 20%
- Final – 30%

**Tentative Schedule**
The following schedule is tentative and subject to change, except for the midterm and final exams.

<table>
<thead>
<tr>
<th>Week</th>
<th>Class Dates</th>
<th>Topics</th>
<th>Hartle Chapters</th>
<th>Problem Set Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>1/25, 1/27</td>
<td>Newtonian Gravity</td>
<td>1-3</td>
<td>2/1</td>
</tr>
<tr>
<td>Week 2</td>
<td>2/1, 2/3</td>
<td>Special Relativity</td>
<td>4</td>
<td>2/8</td>
</tr>
<tr>
<td>Week 3</td>
<td>2/8, 2/10</td>
<td>SR Mechanics, Equivalence Principle</td>
<td>5, 6.1-6.3</td>
<td>2/15</td>
</tr>
<tr>
<td>Week 4</td>
<td>2/15, 2/17</td>
<td>Curved Spacetime</td>
<td>6.4-7.5</td>
<td>2/22</td>
</tr>
<tr>
<td>Week 5</td>
<td>2/22, 2/24</td>
<td>Geodesics</td>
<td>7.6-7.9, 8</td>
<td>3/1</td>
</tr>
<tr>
<td>Week 6</td>
<td>3/1, 3/3</td>
<td>Schwarzschild Geometry</td>
<td>9</td>
<td>3/8</td>
</tr>
<tr>
<td>Week 7</td>
<td>3/8, 3/10</td>
<td>Midterm Review, Exam</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Spring Break</strong></td>
<td>3/15, 3/17</td>
<td>No classes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 9</td>
<td>3/29, 3/31</td>
<td>Gravitational Waves</td>
<td>12.3-12.4, 16</td>
<td>4/5</td>
</tr>
<tr>
<td>Week 10</td>
<td>4/5, 4/7</td>
<td>Expanding Universe</td>
<td>17-18</td>
<td>4/12</td>
</tr>
<tr>
<td>Week</td>
<td>Dates</td>
<td>Topic</td>
<td>Sections</td>
<td>Date</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>--------------------------------------------</td>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>Week 11</td>
<td>4/12, 4/14</td>
<td>Cosmology Tests, Vectors/Tensors</td>
<td>19, 20.1-20.3</td>
<td>4/19</td>
</tr>
<tr>
<td>Week 12</td>
<td>4/19, 4/21</td>
<td>Geodesic Deviation</td>
<td>20.4-21.2</td>
<td>4/26</td>
</tr>
<tr>
<td>Week 13</td>
<td>4/26, 4/28</td>
<td>The Einstein Equation in Vacuum</td>
<td>21.3-22.1</td>
<td>5/3</td>
</tr>
<tr>
<td>Week 14</td>
<td>5/3, 5/5</td>
<td>The Einstein Equation, Final review</td>
<td>22.2-22.4</td>
<td></td>
</tr>
<tr>
<td>Week 15</td>
<td>Thurs 5/12</td>
<td>Final exam</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>