Physics 514: General Relativity, Winter 2021

Preliminary Course Outline – Subject to Revisions

Lectures: Tuesday & Thursday, 10:05am–11:25am from January 5 to April 8. If in-class instruction is allowed, lectures will be held in Rutherford 115. Otherwise, live interactive lectures will take place via Zoom. There will be no class on March 2 or 4 (reading week).

Instructor: Alex Maloney

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- Office Hours: Tuesdays, 11:30am-12:30pm

TAs: TBD

Communications: Course announcements will be sent to registered students at their `mcgill.ca` email address. If you are not registered and would like to get announcements please email me your student ID number so that I can add you to mycourses. Email is the preferred method of communication.

- Course materials (syllabus, problem sets, etc) will be posted on mycourses.
- Video recordings of lectures and lecture notes from a past version of the course are posted at: `http://www.physics.mcgill.ca/~maloney/514`. Some of the lectures this year will differ somewhat from those in previous years.
- If course lectures are delivered online, I will post recordings of these lectures on mycourses.

Grading: Your final grade will be the higher of ($\frac{2}{3}$ Homework+$\frac{1}{3}$ Final) and ($\frac{1}{3}$ Homework+$\frac{2}{3}$ Final). I suspect that the first option will be higher for most students. This grading scheme is preliminary and is subject to revisions. [1][2][3]

- *Problem Sets*: I view the problem sets as the most important component of this course.
  - There will be roughly one problem set per week. They will be posted on mycourses, and will be handed in via the assessment tool in mycourses.
  - You are encouraged to discuss these problems with your colleagues, but you must write up your own solutions; these solutions should reflect your own work and understanding. Some problems will be similar to those I used in previous years when I taught this course and it is possible that some solutions sets are floating around. The use of these or any other solution sets is not allowed; it is considered plagarism and will be treated accordingly.
  - Problem sets which are less than one week late will be penalized 20%, unless an extension has been obtained from me or a TA *before* the due date. Problem sets which are more than one week late will receive a 0.
  - In addition to graded problems, problem sets may include optional problems. These problems will not graded, but I strongly encourage you to at least try them.
- *Final*: There will be a take-home final exam. This final will be open book: you may use the textbook, class notes and problem sets. You may not discuss the final with your colleagues or use

[1] McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures (see www.mcgill.ca/integrity for more information).

[2] In accord with McGill University's Charter of Students Rights, students in this course have the right to submit in English or in French any written work that is to be graded.

[3] In the event of extraordinary circumstances beyond the University's control, the evaluation scheme in a course is subject to change, provided that there be timely communications to the students regarding the change.

the internet, other textbooks or any other outside resources; this is considered cheating and will be treated accordingly.

Prerequisites: I will assume a solid understanding of multivariate calculus, differential equations and linear algebra (at the level of Apostol), special relativity (at the level of Griffiths or the Feynman Lectures), undergraduate mechanics (at the level of Marion & Thornton) and electomagnetism (at the level of Griffiths).

Text: Carrol, "Spacetime and Geometry: An Introduction to General Relativity."

Recommended Reading:

- Schutz, "A First Course in General Relativity." A readable text at more or less the same level as this course. Highly recommended.
- Einstein, "The Meaning of Relativity." Highly recommended.
- Hartle, "Gravity: An Introduction to Einstein's General Relativity." A nice undergraduate text at a lower level than this course.
- Zee, "Einstein Gravity in a Nutshell." Intuitive explanations with many interesting special topics.
- D' Inverno, "Introducing Einstein's Relativity." Well organized alternative to the text.
- Weinberg, "Gravitation and Cosmology." A classic, with a somewhat non-geometrical point of view.
- Misner, Thorne and Wheeler, "Gravitation." Idiosyncratic but with many special topics.
- Wald, "General Relativity." A standard reference. More advanced, with many special topics.
- Hawking and Ellis, "The Large Scale Structure of Space-time." More mathematical, with advanced topics.

Outline: This outline is subject to revisions.

- Introduction (.5 lecture). Special Relativity (1 lecture). The Equivalence Principle (.5).
- Manifolds (1). Tensors (2). Differential Forms (1).
- Metrics (.5). Geodesics (.5). Covariant Derivatives (1). Curvature (2).
- General Relativity (1). The Stress Tensor (1).
- The Lagrangian Formulation (1.5). Symmetries (1.5).
- The Schwarzschild Metric (1.5).
- Tests of GR: Precession of Orbits, Gravitational Lensing and Redshift (1.5).
- Black Holes (2).
- Cosmology (2).
- Linearized Gravity and Gravity Waves (2).
- *Time Permitting*: Hawking Radiation (1).