

PHYSICS 4203 - INTRODUCTION TO GENERAL RELATIVITY

Fall 2023

<https://umsystem.instructure.com/courses/205341>

Description

An introduction to the theory of general relativity. Topics covered include the formalism of general relativity, Einstein's gravitational field equations, the Schwarzschild solution, black holes, and cosmological models of the universe.

Instructor

Professor Marco Cavaglia

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Office hours: Tuesday and Thursday 12:00 p.m. – 1:00 p.m. Please confirm beforehand for availability.

When emailing your instructor, please be polite and address him with his academic title. **Emails with no formal salutation or sign-off will not be answered.** Your instructor will strive to respond to your emails as soon as possible, but please consider that teaching this course is only one of his many duties. So please be patient. If you do not receive a reply within one working day, feel free to send a reminder.

Meeting time and location

Lectures: Monday, Wednesday, and Friday 9:00 a.m. – 9:50 a.m. in Physics 127.

Prerequisites

Physics 2401 or consent of instructor.

Textbook (required)

James B. Hartle, *Gravity: An Introduction to Einstein's General Relativity*, Cambridge University Press; 1st edition (September 2, 2021), ISBN: 9781316517543, url: <https://tinyurl.com/bdv96wuj>.

Objectives

Upon completing this course, the successful student will have a good understanding of the basics concepts of the Theory of General Relativity.

Evaluation

Exams. There will be two midterm exams on **Friday, September 22nd**, and **Friday, October 27th**, during class time. The final exam will be on **Friday, December 15th, from 7:30 a.m. to 9:30 a.m.** The first midterm exam will cover the course material from Monday, August 21, through Wednesday, September 20th (inclusive). The second midterm exam will cover the course material from Monday, September 25th, through Wednesday, October 25th (inclusive). **The final exam will be in two sections. Section (a) is mandatory.** It will cover the material from Monday, October 30th, to the end of the course, Friday, December 8th. **Section (b) is optional.** It will cover the material of the two mid-term exams. If you choose to take it and score better than in any of the mid-term exams, its score will replace the lowest of the two mid-term exam scores.

The exams will consist of a set of simple problems to be worked out. You will be allowed to use a calculator and may be provided with an equation sheet by the instructor. No use of notes or books will be allowed. If you miss an exam because of a civil duty (e.g., jury duty or military service), official university competitions, performances, or travel, religious observations, or certain scheduled medical procedures, they should inform the instructor ahead of time to arrange an accommodation. Missing an exam without prior notification of the instructor may lead to receiving a zero. However, illnesses and other problems, which sometimes occur unexpectedly, may lead to an accommodation in this policy.

Homework. There will be 11 assignments over the course of the semester consisting of two to four problems, each assignment worth 50 points. The 10 best scores will count toward the final grade, i.e., the lowest score will be dropped. Assignments will be announced in class and must be turned in before the date and time they are due. They can be uploaded to Canvas, or a paper copy can be handed over to the instructor. **Late submissions will not be allowed.** However, if there is a valid reason (e.g., due to documented illness), you may be excused from turning in an assignment on time. If you have extended unavoidable absences, the instructor may make some adjustments to the homework policy. Requests for regrades must be submitted before the end of the second class after graded assignments are returned.

Assignments must be easy to read. Please make sure that your assignment is well legible and has your name and assignment number clearly written in the top right corner of all pages. Show all your work; the answer alone is not worth anything. Solutions must be explained in enough text to be understandable. Numerical answers should have units and a reasonable number of significant digits. Keep all returned assignments until the final grade of the course has been posted by the instructor. A violation of the above rules may reduce your grade on the assignment.

Grading

Grade points will be based on assignments and exams as follows:

Homework	500
First mid-term exam	200
Second mid-term exam	200
Final exam (section a)	100
Final exam (section b)	200 ^(*)
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Total	1000

(*) If the score is higher than any of the mid-term exam scores, it replaces the lowest mid-term exam score. Otherwise, it counts as zero.

Grading scale (points):

- A:** 895 and above
- B:** 795 – 894
- C:** 695 – 794
- D:** 595 – 694
- F:** 594 and below

Course attendance policy

This course is Classroom Based. You are required to attend all classes. Please do not arrive late to class or leave early unless you have been previously excused by the instructor. Of course, if you are taken ill during class or in case of an emergency, feel free to leave. However, as soon as you feel better or the emergency is over, let the instructor know why you left. The instructor will not solicit details of the occurrence or any personal

or private information.

Students with inadequate attendance may be dropped. Any student who has inadequate attendance, as evidenced by five confirmed absences or missing a total of five graded assignments of any kind (exams and/or homework), is subject to being dropped if a subsequent class or assignment is missed.

The university requires that all students have their course attendance verified at least once during the first two weeks of the semester. If your attendance is not verified, you will be dropped from the course, and any financial aid will be adjusted accordingly.

Health and well-being

The physical and mental well-being of all students (and of the instructor) takes precedence over any other considerations in this course. The instructor will strive to keep the students safe and healthy. He hopes students will do the same for their well-being as well as the instructor's well-being. While no situation is risk-free, there are easy and effective actions you can take to protect yourself and others around you.

If you're feeling unwell, stay at home. Staying at home until you feel better or have been cleared to return to campus by health officers reduces the risk that you will pass on an illness to your friends, fellow students, your instructor, and others in your community. It will help ensure a smooth educational experience over the semester, as well as reduce the burden on our health services. Please contact Student Health Services at mstshs@mst.edu and/or 573-341-4284, if you become ill or are unable to attend class or take tests on campus.

COVID-19 and other bugs. To protect our campus community and each other from the risks of COVID-19 infection, Missouri S&T strongly encourages all students, faculty, and staff to be up-to-date on COVID-19 vaccinations. A combination of vaccination, staying home when you are sick, and seeking testing when you have symptoms of COVID-19 will be our most effective measures to mitigate against the spread of the virus. There is no requirement to provide proof of immunization, but voluntary reporting of vaccination information at can be done at <https://studenthealth.mst.edu/>. If you are isolating, you will receive an absence note from Student Health and not Student Support and Community Standards (Care Management). You will be responsible of forwarding the absence note to the instructor.

In the event of instructor or campus emergency the course will continue online on the zoom platform.

Academic dishonesty and disruptive behavior

Academic dishonesty and disruptive behavior will not be tolerated and will be dealt with in accordance with university policies. You should familiarize yourselves with the Student Conduct Rules of the University of Missouri in [Section 200](#) of the [Collected Rules](#)

[and Regulations](#) to review the expected standards for student academic integrity, disciplinary procedures, sanctions, and appeal procedures.

In the event of disruptive behavior, the course instructors may request the campus Judicial Officer take effective disciplinary action after issuing a warning. See Student Academic Regulations at <http://registrar.mst.edu/academicregs>.

Disability policy

The Americans with Disabilities Act prohibits discrimination against and guarantees that people with disabilities have the same opportunities as people without a disability. The Missouri University of Science and Technology is committed to providing educational opportunities for all academically qualified students. Reasonable accommodations to ensure equitable access to its programs and services for individuals with disabilities will be made in compliance with the Americans with Disabilities Act.

At the beginning of the semester, students with disabilities who have had their status verified by the Office of Student Disability Services should get in touch with the instructor to go over their specific accommodation requirements.

To learn more about student disability services available to Missouri S&T students, please visit <https://dss.mst.edu/>.

Non-discrimination statement

The University of Missouri does not discriminate on the basis of race, color, national origin, ancestry, religion, sex, pregnancy, sexual orientation, gender identity, gender expression, age, disability, protected veteran status, or any other status protected by applicable state or federal law. The University affirms its commitment to providing equal opportunities by establishing the Equal Opportunity Policy statement in [Section 600.010](#) of the [Collected Rules and Regulations](#). The University's nondiscrimination policies apply to any phase of its employment process, any phase of its admission or financial aid programs, and other aspects of its educational programs or activities.

Additionally, this policy and the existing Title IX policies apply to allegations of sexual misconduct or allegations of other forms of sex discrimination, as defined in [Section 600.020C](#), occurring within the University's educational programs and activities and instances occurring in other settings, including off-campus, if there are effects of the conduct that interfere with or limit students' ability to participate in or benefit from the University's educational programs and activities.

Missouri S&T's Title IX Coordinator is Paul Hirtz. Contact him (hirtz@mst.edu; (573) 341-7734; 900 Innovation Drive - Suite 500) to report Title IX violations. To learn more about Title IX resources and reporting options (confidential and non-confidential) available

to Missouri S&T students, staff, and faculty, please visit <http://titleix.mst.edu>.

Changes to syllabus

If a revision of the syllabus becomes necessary during the semester, it will be discussed in class.

Statement of agreement

Please carefully review and print for your records this syllabus. **By taking this class, you confirm that you have read and understood this document and are agreeable to the policies and provisions set forth therein.**

Appendix: Other resources

Writing Center. The Writing Center's mission is to assist all students in their efforts to become better writers, communicators, and critical thinkers. They offer clients structured one-on-one and small-group conversations with peer consultants. Writing Center consultants are fellow students whose strong writing skills and special training allow them to offer meaningful feedback and guidance for any genre of writing. Students, faculty, and staff across all disciplines can make appointments in-person, online, and asynchronously. More information can be found at their website and through email: writing@mst.edu.

Student Success Center. The Student Success Center (SSC) supports student development through individualized tutoring, peer-to-peer life skill coaching, and campus programming – all while providing free coffee and hot beverages! The SSC was developed to provide additional assistance for students academically and help bolster non-academic life skills, such as goal setting and time-management. All student Miners are encouraged to utilize the SSC's free services to get timely support and to enhance their S&T Miner Experience. Visit the SSC at 198 Toomey Hall, contact us at success@mst.edu, or join us on social media@sandtssc. To see the course offerings and times for SSC Tutoring, visit studentsuccess.mst.edu/tutoring/.

UCARE. UCARE is the central point of contact to connect a student who may be experiencing a personal, academic, financial, wellbeing, and/or other concern to support and resources. Sharing your concern with UCARE helps connect a student with solutionfocused assistance to support their holistic well-being, success, and academic progress. A referral can be submitted at <https://go.mst.edu/ucare-refer> or by emailing ucare@mst.edu. For urgent matters, check out the [after-hour and urgent resources](#).

Assignment schedule

	Lectures	Opens (Friday)	Due (Wednesday)
Assignment 1	August 21, August 23 August 25	August 25	August 30
Assignment 2	August 28, August 30 September 1	September 1	September 6
Assignment 3	September 4, September 6 September 8	September 8	September 13
Assignment 4	September 11, September 13 September 15	September 15	September 20
Assignment 5	September 25, September 27 September 29	September 29	October 4
Assignment 6	October 2, October 4 October 9, October 11 October 13	October 13	October 18
Assignment 7	October 16, October 18 October 20	October 20	October 25
Assignment 8	October 30, November 1 November 3	November 3	November 8
Assignment 9	November 6, November 8 November 10	November 10	November 15
Assignment 10	November 13, November 15 November 17	November 17	November 29
Assignment 11	November 27, November 29 December 1	December 1	December 6