UAB
Universitat Autònoma de Barcelona

General Relativity and Cosmology

2026/2027

Code: 103946
Credits: 6

Degree programme	Type	Course
Physics	OP	4

Contact lecturer

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Group languages

You can consult this information at the end of the document.

Prerequisites

Warmly recommended prerequisites: analytical mechanics, classical electrodynamics.

Objectives

To learn the physical basis of General Relativity (GR) as well as the most important gravitational phenomena that are described with it.
This goal requires mastering tensor calculus.
The classical tests of GR and the familiarization with the most important spacetimes are also included as part of the course.

Learning outcomes

1. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
2. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
3. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
4. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
5. Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.
6. Use space-time symmetries for solving problems of dynamics and relativistic kinematics.
7. Obtain physical magnitudes measured by different observers from pseudo-Riemannian metrics.
8. Calculate the effect of red shift and the deflection of light produced by a gravitational field.
9. Calculate particle trajectories in gravitational fields solving the geodesic equation.
10. Calculate the simple-distribution energy-momentum tensor for matter.
11. Obtain tidal forces from the curvature tensor.
12. Relate general relativity and electromagnetism establishing their similarities and differences.
13. Describe gravitational waves and their characteristic properties.
14. Describe the characteristics of the gravitational field generated by stars and black holes in addition to the effects they produce.
15. Describe the basic concepts of current knowledge regarding the structure and evolution of the universe.
16. Establish the bases for describing the evaporation and thermodynamics of black holes.
17. Obtain the Newtonian limit of Einstein's equations with weak non-relativistic sources.

18. Use Einstein's equations in a linearized manner so as to describe weak gravitational fields, including the generation, propagation and detection of gravitational waves.
19. Use the approximation of spherical symmetry in the study of stars and black holes.
20. Use the approach of homogeneity and isotropy to describe the structure and evolution of the universe on a large scale.
21. Use covariant equations and tensor calculus.
22. Calculate the geodesics in a curved space.
23. Calculate curvature tensor.
24. Use differential geometry to implement the principle of equivalence.
25. Describe experimental evidence in favor of general relativity and the principle of equivalence in terrestrial and astrophysical observations.
26. Describe experimental evidence for the existence of gravitational waves.
27. Describe observational evidence in favour of big bang cosmology.
28. Identify situations in which a change or improvement is needed.
29. Identify the social, economic and environmental implications of academic and professional activities within one's own area of knowledge.

Contents

Selected topics in Special Relativity

The Equivalence Principle

Tensor calculus

Einstein's equations

Spherical symmetry. Black holes

Weak fields. Gravitational radiation

Introduction to Cosmology

Learning activities and methodology

Title	Hours	ECTS	Learning outcomes
Theory lectures	33	1.32	2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
Study of theoretical	47	1.88	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,

foundations			24, 25, 26, 27
Discussion and work in group	46	1.84	2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27
Problem lectures and discussion	16	0.64	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24

This course will be given entirely in English. All the course material (problems, homework and exams) will be distributed in English

and students will be encouraged to do all the exercises/exams in English, although Catalan or Spanish

will also be accepted and assesed with the same criteria.

This course will consist of theory and problem classes. There will be balance among work in class and at home.

Problem lists will be given to be solved individually or in groups. The solutions to the problelms will be discussed in the problem classes, with active participation of students.

Annotation: within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continuous assessment activities

Title	Weight	Hours	ECTS	Learning outcomes
Exam 2	45%	2	0.08	2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29
Exam 1	35%	2	0.08	2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29
Homework	20%	2	0.08	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 16, 17, 18, 19, 20, 21, 22, 23, 24
Resit Exam	80%	2	0.08	2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27

Midterm Exam: 35% of the grade

Final Exam: 45% of the grade

Seminar presentation: 20% of the grade. It will take place during the second half of the course, before the final exam. Students will organize in small groups, each one preparing at home a presentation on a topic from a list that will be provided. They will then present it in front of the instructors.

There will be a resit exam for students that: a) have done the midterm and final exams and b) have failed the course with a mark of at least 3.0 (over 10). The resit exam will be on all topics of the course, and will allow to improve on the average grade from the two partial exams (80% of the total grade).

Depending on the number of students and on the specific grade of each student, the possibility to do an oral exam (possibly preceded by a shorter written exam) may be proposed. These details will be announced in due course during the semester, with sufficient advance.

Students not attending Exam 2 will have the mark \"Not presented - no avaluable\"

Single assessement

The students that opted for single assessment evaluation will have to perform a final evaluation that will first consist of a test of the whole syllabus. This test will take place on the same date, time and place as the second term test of the continuous assessment modality. The student will still be allowed to participate in the seminar presentations to obtain the 20% of their final grade. If they cannot participate, they will do a presentation before their exam.

For the mark, 80% of the final mark will come from the exam and the presentation will count 20%.

The students that opted for single assessment evaluation will have the chance of passing the module or improve their mark at the same re-evaluation test as the students that had opted for the continuous assessment option (both exams will be of the same type and will take place on the same day, time and in the same place), but it is mandatory to at least have taken the previous final test, with a minimum grade of 3.0. Only 80% of the grade can be improved at the final exam.

Bibliography

- S. Weinberg, Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, J. Wiley & Sons, 1972.

- J.B. Hartle, Gravity: an Introduction to Einstein's General Relativity, Addison-Wesley, 2003.

- B.F. Schutz, A First Course in General Relativity, Cambridge Univ Press, 2009.

Additional references and material will be provided during the course.

Software

No "programari"

Course groups and languages

The information provided is provisional until November 30. After this date, you will be able to consult the language of each group through this link. To access the information, you will need to enter the course CODE

Type of teaching	Group	Language	Semester	Shift
(TE) Theory	1	English	second semester	morning-mixed
(PAUL) Classroom practices	1	English	second semester	morning-mixed