UAB
Universitat Autònoma de Barcelona

General Relativity and Cosmology

Code: 103946
ECTS Credits: 6

2025/2026

Degree	Type	Year
Physics	OT	4

Contact

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Teaching groups languages

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

Prerequisites

Warmly recommended prerequisites: analytical mechanics, classical electrodynamics.

Objectives and Contextualisation

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.

Competences

- Apply fundamental principles to the qualitative and quantitative study of various specific areas in physics
- Be familiar with the bases of certain advanced topics, including current developments on the parameters of physics that one could subsequently develop more fully
- Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Formulate and address physical problems identifying the most relevant principles and using approximations, if necessary, to reach a solution that must be presented, specifying assumptions and approximations
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation

- Using appropriate methods, plan and carry out a study or theoretical research and interpret and present the results
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project
- Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.

Learning Outcomes

1. Calculate curvature tensor.
2. Calculate particle trajectories in gravitational fields solving the geodesic equation.
3. Calculate the effect of red shift and the deflection of light produced by a gravitational field.
4. Calculate the geodesics in a curved space.
5. Calculate the simple-distribution energy-momentum tensor for matter.
6. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
7. 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.
8. Describe experimental evidence for the existence of gravitational waves.
9. Describe experimental evidence in favor of general relativity and the principle of equivalence in terrestrial and astrophysical observations.
10. Describe gravitational waves and their characteristic properties.
11. Describe observational evidence in favour of big bang cosmology.
12. Describe the basic concepts of current knowledge regarding the structure and evolution of the universe.
13. Describe the characteristics of the gravitational field generated by stars and black holes in addition to the effects they produce.
14. Establish the bases for describing the evaporation and thermodynamics of black holes.
15. Identify situations in which a change or improvement is needed.
16. Identify the social, economic and environmental implications of academic and professional activities within one's own area of knowledge.
17. Obtain physical magnitudes measured by different observers from pseudo-Riemannian metrics.
18. Obtain the Newtonian limit of Einstein's equations with weak non-relativistic sources.
19. Obtain tidal forces from the curvature tensor.
20. Relate general relativity and electromagnetism establishing their similarities and differences.
21. Use covariant equations and tensor calculus.
22. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
23. Use differential geometry to implement the principle of equivalence.
24. Use Einstein's equations in a linearized manner so as to describe weak gravitational fields, including the generation, propagation and detection of gravitational waves.
25. Use space-time symmetries for solving problems of dynamics and relativistic kinematics.
26. Use the approach of homogeneity and isotropy to describe the structure and evolution of the universe on a large scale.
27. Use the approximation of spherical symmetry in the study of stars and black holes.
28. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
29. Working in groups, assume shared responsibilities and interact professionally and constructively with others, showing absolute respect for their rights.

Content

Selected topics in Special Relativity

The Equivalence Principle

Tensor calculus

Einstein's equations

Spherical symmetry. Black holes

Weak fields. Gravitational radiation

Introduction to Cosmology

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problem lectures and discussion	16	0.64	1, 5, 3, 4, 2, 7, 12, 13, 10, 14, 6, 18, 19, 17, 22, 20, 28, 29, 21, 23, 27, 26, 24, 25
Theory lectures	33	1.32	1, 5, 3, 4, 2, 7, 12, 13, 10, 8, 9, 11, 14, 18, 19, 17, 22, 20, 21, 23, 27, 26, 24, 25
Type: Autonomous			
Discussion and work in group	46	1.84	1, 5, 3, 4, 2, 7, 12, 13, 10, 8, 9, 11, 18, 19, 17, 22, 20, 29, 21, 23, 27, 26, 24, 25
Study of theoretical foundations	47	1.88	1, 5, 3, 4, 2, 7, 12, 13, 10, 8, 9, 11, 14, 6, 18, 19, 17, 22, 20, 28, 21, 23, 27, 26, 24, 25

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 in 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

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes

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

Midterm Exam: 35% of the grade
Final Exam: 45% of the grade
Homework (or seminar presentation, depending on the number of students): 20% of the grade. It will take place during the semester, before the final exam.
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 (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 assessement 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. Besides, before the exam, the student will deliver 1 document with a solved problem set proposed at an earlier date.
For the mark, 80% of the final mark will come from the exam and the problem set will count 20%.
The students that opted for single assessement evaluation willhave 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 assessement 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"

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	1	English	second semester	afternoon
(TE) Theory	1	English	second semester	afternoon