Faculty of Science

FYSN28, Physics: General Relativity, 7.5 credits

Fysik: Allmän relativitetsteori, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus was approved by The Education Board of Faculty of Science on 2025-04-22. The syllabus comes into effect 2025-04-22 and is valid from the spring semester 2026.

General information

The course is an elective course for second-cycle studies for a Degree of Master of Science (120 credits) with a specialisation in physics.

Language of instruction: English

Main field of study	*Specialisation*
Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements

Learning outcomes

The aim of the course is to give the student an introduction to Einstein's theory of general relativity. The course includes the basic physical ideas, the necessary mathematics and a number of applications, for example bending of light, planetary motion, black holes, gravitational waves and cosmology.

Knowledge and understanding

Upon completion of the course the student shall be able to:

- explain the concepts spacetime and spacetime's geometry
- explain the concept of tensors
- explain the equivalens principle and how it leads to curved spacetime
- explain the new concepts required, especially metrics, prallel transport and the Riemann tensor

- write down Einstein's equations och from physical principles argue for the different terms
- formulate Einstein's equations in the weak field approoximation
- explain astronomical and cosmological applications of Einstein's equations. for examples black holes and the expansion of the universe
- Explain the concept of a geodesic
- explain the most relevant experimental proofs of general relativity

Competence and skills

Upon completion of the course the student shall be able to:

- handle the flat spacetime of special relativity
- apply the concept of tensors
- show how the mathematics of a curved spacetime can be built up with minimal modifications of a flat spacetime
- apply Einstein's equations in the weak field approximation to derive Newtons law of gravitation and gravitational waves
- simplify the metric for highly symmetric and/or static spacetime and solve Einstein's equations in those cases
- apply the geodesic equation to calculate geodesics given a metric
- apply conserved quantities to analyze possible orbits in a given curved spacetime
- given a metric, show whether it represents a flat or curved space-time, state conserved quantities and calculate the Christoffel symbols and the Riemann tensor
- given the metric of a highly symmetric space-time, analyse possible orbits and examine whether the space-time contains horizons

Judgement and approach

Upon completion of the course the student shall be able to:

- assess when Einstein's equations are necessary or when Newton's equations are sufficient
- argue for the existence of Hawking's black hole radiation

Course content

The course consists of the following:

- Special relativity and flat spacetimes
- Tensors
- Equivalence principle
- Curved spacetime
- Einstein's equations
- Weak field approximation

- Very symmetric and/or static spacetimes
- Geodesics
- Conservation laws
- Experimental tests

Course design

The teaching consists of lectures, exercises and seminars. Participation in the seminar where the student presents is mandatory.

Assessment

The examination takes the form of an oral seminar assignment and written hand-in assignments during the course and an oral test at the end of the course.

Students who do not pass the regular exam are offered a new possibility shortly after the regular exam.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Grades

Grading scale includes the grades: Fail, Pass, Pass with distinction
The grading scale for the seminar assignment is Fail, Pass, while assignments and exam are graded according to the grading scale Fail, Pass, Pass with distinction.

For a Pass grade on the whole course, the student must have Pass grades on the oral seminar assignment, written hand-in assignments and the oral test.

The final grade is determined by combining the results of the assignments and the exam.

Entry requirements

Admission to the course requires 75 credits in physics and 45 credits in mathematics, or a bachelor's degree in physics or equivalent. General entry requirements and English 6/B.

Further information

Assumed prior knowledge: Knowledge corresponding to FYTB14 Classical mechanics and special relativity, 7,5 credits is recommended.

The course replaces FYTN08 and may not be credited towards a degree together with it.

The course is offered at the Department of Physics, Lund University.