Faculty of Science

ASTM29, Astronomy: Statistical Tools in Astrophysics, 7.5 credits

Astronomi: Statistiska verktyg i astrofysiken, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus is an old version, approved by Study programmes board, Faculty of Science on 2021-01-31 and was valid from 2021-01-31 , autumn semester 2021.

General Information

The course is a compulsory course for second-cycle studies for a Degree of Master of Science (120 credits) in astrophysics. The course belongs to is the main fields of physics and astrophysics at the faculty of Science and is given by the department of Astronomy and theoretical physics. The course can also be taken as a stand alone course or as part of any bachelor or master program in physics or related fields.

Main field of studies	*Depth of study relative to the degree requirements*
Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements
Astrophysics	A1N, Second cycle, has only first-cycle course/s as entry requirements

Learning outcomes

The overall aim of the course is to give the student knowledge und understanding of statistical techniques that are used in the analysis of data sets in various fields, with applications taken from astrophysics. The aim is also to give the student knowledge of concepts underpinning these techniques, as well as the skill to use them on data.

References to aims targeting the intended learning outcomes in the programme syllabus of Degree of Master in Astrophysics are as given below:

- Aims 1-12 target the intended learning outcome 1a.I in the programme syllabus.
- Aims 7-12 target the intended learning outcome 1b in the programme syllabus.

- Aims 1-12, 15-17 target the intended learning outcome 2 in the programme syllabus.
- Aim 15 targets the intended learning outcome 3.I in the programme syllabus.
- Aim 14 targets the intended learning outcome 3.II in the programme syllabus.
- Aims 7, 9, 11 and 13 target the intended learning outcome 5 in the programme syllabus.

Knowledge and understanding

On completion of the course, the student shall be able to:

1. Recognise and explain basic concepts in probability theory and statistical tools.
2. Identify and compare a number of the most important discrete and continuous probability distributions and their application in physics.
3. Describe numerical methods used to generate pseudo random numbers with different distributions.
4. Identify and discuss common graphical methods to present data, distributions and uncertainties, and their advantages and disadvantages.
5. Explain and discuss the principle of maximum likelihood.
6. Explain and discuss the meaning of confidence intervals and similar estimates of uncertainty.

Competence and skills

On completion of the course, the student shall be able to:

7. Compute and interpret elementary statistical data.
8. Apply the maximum likelihood method on simple estimation problems.
9. Fit a non-linear mathematical model to given data.
10. Derive confidence intervals in estimation and fitting problems.
11. Analyse irregular time series to find periodic variations.
12. Apply hypothesis tests in relation to simple models.
13. Write computer programmes which use statistical tools to analyse data.
14. Plan their work to complete computing exercises within given time frames.

Judgement and approach

On completion of the course, the student shall be able to:

15. Identify and formulate statistical issues critically, autonomously and creatively.
16. Interpret results from the analysis of uncertain data
17. Organize and justify their presentation of uncertain data.

Course content

The course contains the following parts:

- Basic probability theory and statistics.
- The concept of probability, probability distributions and Bayes' theorem.
- Sampling, moments, correlation, and order statistics.
- Graphical presentation of data.
- Parameter estimation and model fitting.
- The maximum likelihood principle and the least squares method.
- Signal, noise, errors and uncertainties.
- Uncertainty estimates and confidence intervals.
- Monte Carlo methods.

- Hypothesis testing.
- Periodograms for regular and irregular time series.

Course design

The teaching consists of lectures and exercises. In the exercises, given data are analysed by means of computer programs that the students develop themselves, based on the described statistical and numerical tools.

Reports on the exercises have deadlines during the teaching period. Formative feedback is given on the reports in the form of written comments on the individual reports, and discussion in lectures. This feedback includes comments on time planning and code writing, which the students can apply to following exercises.

Participation in the exercises and associated teaching is compulsory.

Assessment

The assessment consists of written reports on the exercises, which assess intended learning outcomes 7-17, as well as the final written exam, which assesses intended learning outcomes 1-6.

Students who do not pass an assessment will be offered another opportunity for assessment soon thereafter.

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.

Subcourses that are part of this course can be found in an appendix at the end of this document.

Grades

Marking scale: Fail, Pass, Pass with distinction.
For a grade of pass on the whole course, the student must have passed reports from all of the exercises, a passed final examination, and participation in all compulsory course elements.

The final examination and each of the reports on exercises are graded on a scale from 0 to 100%, where at least 50% is required to pass.

The final grade is decided by as a weighted average of the final examination grade and the grades for the reports on exercise. The weights are chosen so that reports on exercises account for 2/3 of the final result and the written examination 1/3. For the grade pass with distinction, a weight average mark of at least 75% is required.

Entry requirements

To be admitted to the course, students must have 75 credits in Physics and 45 credits in Mathematics, or a Bachelor of Science in Physics.

Further information

The course may not be included in a higher education qualification together with ASTM11 Statistical and numerical tools in astrophysics I (7.5 credits) or ASTM21 Statistical tools in Astrophysics (7.5 credits)

Subcourses in ASTM29, Astronomy: Statistical Tools in Astrophysics

Applies from H21

2101 Written exam, 2,5 hp
Grading scale: Fail, Pass, Pass with distinction
2102 Projects, 5,0 hp
Grading scale: Fail, Pass, Pass with distinction