

**COURSE DATA****DATA SUBJECT****Code:** 34261**Name:** Astrophysics**Cycle:** Undergraduate Studies**ECTS Credits:** 4.5**Academic year:** 2025-26**STUDY (S)**

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Facultat de Física	3	First quarter
1928 - Double Degree Program Physics-Mathematics	Facultat de Ciències Matemàtiques	4	Second quarter
1929 - Double Degree Program in Physics and Chemistry	Facultat de Física	4	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1105 - Degree in Physics	Physics of the earth and the cosmos	COMPULSORY
1928 - Double Degree Program Physics-Mathematics	Cuarto Curso (Obligatorio)	COMPULSORY
1929 - Double Degree Program in Physics and Chemistry	Cuarto Curso (Obligatorio)	COMPULSORY

COORDINATION

MARTI PUIG JOSE MARIA

ALOY TORAS MIGUEL ANGEL

MARTINEZ GARCIA VICENT JOSEP

SUMMARY

The subject 'Astrophysics' is compulsory and belongs to the module 'Physics of the Earth and the Cosmos'. Its contents are taught during the first semester of the Third Year of the Physics Degree and the Fourth Year of the Double Degree in Physics-Chemistry, as well as during the second semester of the Fourth Year of the Double Degree in Physics-Mathematics, with 4.5 ECTS credits. In 'Astrophysics', the methods and knowledge of modern physics are used to study the movement, structure, composition, and evolution of the celestial bodies in the universe, from the objects of the Solar System to the stars and the galaxies. The course begins presenting basic concepts of positional astronomy to locate the astronomical objects on the celestial sphere and to understand their apparent movements. We also introduce the fundamental



techniques of astronomical observation. Further on a description of the Solar System and its components is presented and the discovery of exoplanets is explained. The third theme of the subject is devoted to the study of the stars. The parameters needed to characterize the stars and their structure and evolution are studied. Finally, our galaxy and the other galaxies populating the universe are analysed, introducing highly relevant aspects in current astronomical research such as dark matter, active galaxies, and supermassive black holes. Finally, in the last topic, we present basic notions of Cosmology, the science that studies the universe as a whole, its origin and its evolution, introducing the Big Bang model as well as the current cosmological paradigm supported by present day observations: a flat universe in accelerated expansion. Those students who wish to expand their knowledge in this field, within the offer of optional subjects in the Physics Degree, should study 'Observational Astrophysics' and 'Relativity and Cosmology' in the Fourth Course.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

It is advised to have completed the first two years of the degree. All the specific subjects of Physics are important for this course. Specific subjects of Mathematics are also important, in particular Integral Calculus and Differential Equations.

It should be emphasized that Astrophysics is, by its very nature, a field of science where most of the specialties of Physics converge.

COMPETENCES / LEARNING OUTCOMES

-

Basic & applied Research: acquire an understanding of the nature and ways of physics research and of how physics research is applicable to many fields other than physics, e.g. engineering; be able to design experimental and/or theoretical procedures for: (i) solving current problems in academic or industrial research; (ii) improving the existing results.

Be able to understand and master the use of the most commonly used mathematical and numerical methods.

Communication Skills (written and oral): Being able to communicate information, ideas, problems and solutions through argumentation and reasoning which are characteristic of the scientific activity, using basic concepts and tools of physics.

Foreign Language skills: Have improved command of English (or other foreign languages of interest) through: use of the basic literature, written and oral communication (scientific and technical English), participation in courses, study abroad via exchange programmes, and recognition of credits at foreign universities or research centres.



Knowledge and understanding of the fundamentals of physics in theoretical and experimental aspects, and the mathematical background needed for its formulation.

Learning ability: be able to enter new fields through independent study, in physics and science and technology in general.

Modelling & Problem solving skills: be able to identify the essentials of a process / situation and to set up a working model of the same; be able to perform the required approximations so as to reduce a problem to an approachable one. Critical thinking to construct physical models.

Physics general culture: Be familiar with the most important areas of physics and with those approaches which span many areas in physics, or connections of physics with other sciences.

Problem solving: be able to evaluate clearly the orders of magnitude in situations which are physically different, but show analogies, thus allowing the use of known solutions in new problems .

Students must be able to apply their knowledge to their work or vocation in a professional manner and have acquired the competences required for the preparation and defence of arguments and for problem solving in their field of study.

Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.

Students must have acquired knowledge and understanding in a specific field of study, on the basis of general secondary education and at a level that includes mainly knowledge drawn from advanced textbooks, but also some cutting-edge knowledge in their field of study.

Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.

Students must have the ability to gather and interpret relevant data (usually in their field of study) to make judgements that take relevant social, scientific or ethical issues into consideration.

Theoretical understanding of physical phenomena: have a good understanding of the most important physical theories (logical and mathematical structure, experimental support, described physical phenomena).

To know how to apply the knowledge acquired to professional activity, to know how to solve problems and develop and defend arguments, relying on this knowledge.

DESCRIPTION OF CONTENTS

1. Motions of planets and stars.

General introduction. Equations and properties of the movements. Equation of the orbits. Elements of the orbit. Scape velocity. The two-body problem. Restricted three-body problem and mass-transfer in binary systems. The virial theorem.



2. The Solar System.

General properties. The formation of the Solar System. Structure of the planets. Atmospheres. Magnetospheres. The Sun. Planets and asteroids. Comets, the Oort's cloud and the Kuiper's belt.

3. Exoplanets and Astrobiology.

Methods of exoplanet detection. Properties and habitability. Introduction to astrobiology.

4. Stars. Stellar parameters. Spectral Classification.

Magnitudes. Stellar parameters: masses, luminosities, temperatures and radii. Mass-luminosity relationship. Spectral lines. Spectral classification: spectral types and luminosity classes. Hertzsprung-Russell diagram.

5. Radiative transfer.

Intensity and flux. Radiative transfer equation: conservation, emission and absorption. Radiation force. Blackbody radiation and thermal radiation. Diffusion approximation.

6. Stellar structure.

Equation of state. Hydrostatic balance. Production of energy in the stellar interior: nuclear reactions and reaction rates. Stellar nucleosynthesis. Energy balance. Sources of opacity and temperature gradient. Stellar structure equations and stellar models.

7. Stellar evolution.

Characteristic time scales. Star formation and protostellar evolution. Main sequence stage. Evolution towards red giant. Late evolutionary stages according to star mass and evolution in binary systems. Novae, supernovae, neutron stars, white dwarfs and black holes.

8. Galactic astronomy.

Distance measurements and stellar statistics. Structure and general characteristics of the Galaxy. The galactic center. Galactic kinematics and dark matter.



9. Extragalactic astronomy.

The discovery of other galaxies. Extragalactic distance indicators. Classification of galaxies. Stellar populations. Dark matter. Photometric properties. Active galaxies and supermassive black holes. Clusters and groups of galaxies.

10. Cosmology.

Expansion of the universe. Hubble-Lemaître's Law. Age of the universe. Critical density. Cosmological equations. Distances in cosmology. Cosmic background radiation. Density of matter and radiation. The early universe. Thermal history. Primordial nucleosynthesis. Dark energy. Current cosmological paradigm: accelerated flat universe.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	7,00
Theory	38,00
Total hours	45,00

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	0,00
Preparation of lessons	52,50
Preparation for assessment activities	15,00
Resolution of case studies	0,00
Total hours	67,50

TEACHING METHODOLOGY

Contact teaching 40%

Theoretical and practical classes: It addresses the conceptual and formal matter and resolution of problems or cases as the application of theoretical concepts. They are based mainly on lectures with dialogue and the use of teaching tools such as experimental demonstrations, animations or videos, graphic solutions, projected presentations, etc.)..

Group tutoring sessions or work in small groups: focus on student work and their active participation: resolving doubts in dealing with theoretical concepts and problem solving, reinforcement in areas of



greatest difficulty, questionnaires conceptual , experimental demonstrations relevant to the case studies and associated with a component of continuous assessment, verification of student progress in the field.

Student's personal work 60%

- Study of the theoretical foundations.
- Resolution and problems, multiple choice questions, and works (individually or in groups)
- Individual tutorials: querying of the teacher on student concerns and difficulties encountered in the study and resolution of problems, or discussion on topics of interest, bibliography, etc.

EVALUATION

The evaluation methods are as follows:

1. Written exams:

- One part will assess the understanding of theoretical and conceptual aspects, as well as the formalism of the subject, through theoretical questions, conceptual or numerical problems, or simple particular cases.
- Another part will evaluate the ability to apply the formalism through problem solving, as well as critical thinking regarding the results obtained.
- In both parts, correct reasoning and appropriate justification will be assessed.

2. Continuous assessment:

- Two 30-minute quizzes carried out during lecture sessions.
- The questions for the quizzes will be taken from a list previously provided to the students.
- Continuous assessment may also include oral presentations of solved problems or any other method that involves interaction between lecturers and students.

Remarks:

The final grade will be the higher of the following two: the grade of the written exam, or the weighted average of 75% of the written exam and 25% of the continuous assessment. However, the minimum required grade in the written exam to pass the subject is 3.5 out of 10.

The grade from the continuous assessment will be valid for both examination periods within the academic year. The weightings of continuous assessment and exams are the same in both the first and second calls.



REFERENCES

Basic

- Carroll, B. W., Ostlie, D. A., *An Introduction to Modern Astrophysics*, Cambridge University Press, 2nd edition, 2017.
- Karttunen, H., Kröger, P., Oja, H., Poutanen, M., Donner, K. J., *Fundamental Astronomy*, Springer, 6th edition, 2017.
- Martínez, V. J., Miralles, J. A., Marco, E., Galadí-Enríquez, D., *Astronomía Fundamental*, Publicacions de la Universitat de València, 2005.

Additional

- Clayton, D. D., *Principles of Stellar Evolution and Nucleosynthesis*, University of Chicago Press, 1983.
- Hansen, C. J., Kawaler, S. D., *Stellar Interiors*, Springer, 1994.
- Kippenhahn, R. Weigert, A., *Stellar Structure and Evolution*, Springer, 1990.
- Rybicki, G. B., Lightman, A. P., *Radiative Processes in Astrophysics*, Wiley, 1979.
- Schneider, P., *Extragalactic Astronomy and Cosmology. An Introduction*, Springer, 2nd edition, 2015.
- Shapiro, S. L., Teukolsky, S. A., *Black holes, White Dwarfs and Neutron Stars: The Physics of Compact Objects*, Wiley-WCH, 1983.
- Shu, F. H., *The Physics of Astrophysics. Volume I. Radiation*, University Science Books, 1991.
- Sparke, L. S., Gallagher, J. S., *Galaxies in the Universe. An Introduction*, Cambridge University Press, 2000.
- Ryden, B., *Introduction to Cosmology*, 2nd edition. Cambridge University Press, 2017.
- Perlov, B., Vilenkin, A., *Cosmology for the Curious*, Springer-Verlag, 2017.
- Martínez, V.J., Saar, E., *Statistics of the Galaxy Distribution*, Chapman & Hall/CRC Press, Boca Raton, 2002.
- Lang, K.R, *Essential Astrophysics*, Springer-Verlag, Berlin, 2013.



- Keaton, C., *Principles of Astrophysics*, Springer-Verlag, New York, 2014.
- Díaz Beltrán, A.I., *Estrellas y Galaxias*, Akal, 2019.
- Owocki, S., *Fundamentals of Astrophysics*, Cambridge University Press, 2021.