COURSE DATA

Data Subject	
Code	34261
Name	Astrophysics
Cycle	Grade
ECTS Credits	4.5
Academic year	2024 - 2025

Study (s)

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Faculty of Physics	3	First term
1928 - Double Degree Program Physics-Mathematics	Double Degree Program Physics and Mathematics	4	First term
1929 - Double Degree Program in Physics and Chemistry	Double Degree Program Physics and Chemistry	4	First term

Subject-matter

Degree	Subject-matter	Character
1105 - Degree in Physics	14 - Physics of the earth and the cosmos	Obligatory
1928 - Double Degree Program Physics-Mathematics	4 - Cuarto Curso (Obligatorio)	Obligatory
1929 - Double Degree Program in Physics and Chemistry	4 - Cuarto Curso (Obligatorio)	Obligatory

Coordination

Name	Department
ALOY TORAS, MIGUEL ANGEL	16 - Astronomy and Astrophysics
MARTI PUIG, JOSE MARIA	16 - Astronomy and Astrophysics
MARTINEZ GARCIA, VICENT JOSEP	16 - Astronomy and Astrophysics

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 required 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 (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

1105 - Degree in Physics

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

- 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.
- 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 .
- Theoretical understanding of physical phenomena: have a good understanding of the most important physical theories (logical and mathematical structure, experimental support, described physical phenomena).
- Be able to understand and master the use of the most commonly used mathematical and numerical methods.
- 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.
- 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.
- 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.
- Learning ability: be able to enter new fields through independent study, in physics and science and technology in general.
- 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.
- 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 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 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.
- Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.

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

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

- Theoretical understanding of physical phenomena: Know and understand the foundations of astrophysics and cosmology, as well as the mathematical baggage for its formulation and the physical phenomena involved and the most relevant applications.

- Modeling and problem solving: Being able to evaluate the orders of magnitude of the relevant variables of each problem, to identify the essential elements of each physical situation and to carry out the required approximations in order to reduce the problems to a manageable modeling level. Being able to develop a perception of situations that are physically different but that show analogies, thus allowing the application of known solutions to new problems.

- General Culture in Physics: Be familiar with the most important aspects of astrophysics and cosmology, and with approaches that cover and relate different areas of physics.

- General and Specific Foreign Language Skills: Improve the command of scientific-technical English by reading and accessing the fundamental bibliography of the subject.

- Be able to continue studying other subjects in physics thanks to the baggage acquired in the context of this subject.

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 Oorts cloud and the Kuipers 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

ACTIVITY	Hours	% To be attended
Theory classes	38,00	100
Tutorials	7,00	100
Preparation of evaluation activities	15,00	0
Preparing lectures	37,50	0
Preparation of practical classes and problem	15,00	0
TOTAL	112,50	

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 assessment system is as follows:

1) Written examinations: One part will assess the understanding of the theoretical-conceptual and formal nature of the subject, both through theoretical questions, conceptual questions and numerical or simple particular cases. Another part will assess the applicability of the formalism, by solving problems and critical capacity regarding the results. Proper argumentations and adequate justifications will be important in both cases.

2) Continuous assessment: assessment of exercises and problems presented by students, questions proposed and discussed in class, oral presentation of problems solved or any other method that involves an interaction with students.

COMMENTS:

The final grade will be the highest of the written exam grade and the result of adding the written exam grade multiplied by 0,65 and the continuous assessment grade multiplied by 0,35. However, the minimum mark in the exam to have the option to pass the course is 3,5 out of 10.

REFERENCES

Basic

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- Díaz Beltrán, A.I., Estrellas y Galaxias, Akal, 2019
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Additional

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- Hansen, C. J., Kawaler, S. D., Stellar Interiors, Springer, 1994
- Kippenhahn, R. Weigert, A., Stellar Structure and Evolution, Springer, 1990
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