COURSE DATA

Data Subject	
Code	34244
Name	Mechanics II
Cycle	Grade
ECTS Credits	7.5
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Faculty of Physics	2	Second term
1928 - D.D. in Physics-Mathematics	Double Degree Program Physics and Mathematics	3	Second term
1929 - D.D. in Physics-Chemistry	Double Degree Program Physics and Chemistry	3	First term

Subject-matter

Degree	Subject-matter	Character
1105 - Degree in Physics	6 - Mechanics and waves	Obligatory
1928 - D.D. in Physics-Mathematics	3 - Tercer Curso (Obligatorio)	Obligatory
1929 - D.D. in Physics-Chemistry	3 - Tercer Curso (Obligatorio)	Obligatory

Coordination

Name	Department
FABBRI, ALESSANDRO	185 - Theoretical Physics
HERRERO GARCIA, JUAN ANDRES	185 - Theoretical Physics
LOPEZ PAVON, JACOBO	185 - Theoretical Physics

SUMMARY

The course develops the key tools of advanced classical mechanics and relativity theory. We will cover fundamental results of Newtonian mechanics in greater depth, introduce the Lagrange and Hamiltonian formulations of mechanics, variational principles, Hamilton-Jacobi theory, and introductory notions of integrability and chaos. We will study in depth the theory of special relativity, including Einstein's equivalence principle, and its main physical implications.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

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

Other requirements

Suggested prerequisite knowledge: General Physics, Calculus I and II (or Mathematical Analysis I F-M and Vector Calculus), Differential equations, and Mechanics I. Students are encouraged to attend previusly or simultaneously the course: Oscillations and Waves.

OUTCOMES

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.
- 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

The main aim of the course is to provide a strong background in advanced classical mechanics and relativity theory.

DESCRIPTION OF CONTENTS

1. Lagrangian and Hamiltonian Mechanics

Generalized coordinates. Constraints. Lagranges equations. Hamiltons variational principle. Charged particle in an electromagnetic field. Symmetries and conservation laws. Noethers theorem. Hamiltons equations. Phase space. Poisson brackets. Canonical transformations. Liouvilles theorem. Symmetries in phase space. The Hamilton-Jacobi formalism. Separation of variables. Action-angle variables. Completely integrable systems. Transition to chaos.

2. Relativity

The Michelson-Morley experiment. Einsteins two axioms of special relativity. Time dilation and length contraction. Simultaneity. Space-time diagrams. Lorentzs transformations. Velocity transformation rules. The Doppler effect and aberration. Relativistic momentum and energy. Equivalence mass-energy. The Minkowski space-time. 4-velocity and 4-momentum. Causality. Relativistic charged particle in an electromagnetic field. Collisions and decays of particles. Einsteins equivalence principle. Transition to general relativity.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	60,00	100
Tutorials	15,00	100
Development of individual work	30,00	0
Study and independent work	82,50	0
TOTAL	**187,50**	

TEACHING METHODOLOGY

We have four regular lectures per week , according to the timetable assigned by the Faculty of Physics. These lectures will cover the topics of the course. We will explain the general theory in class (together with illustrative examples). We leave detailed examples for the homework assignments. The homeworks are absolutely essential for understanding the course material. It is extremely important for students to work them out by themselves. Homework will be assigned once 1-2 weeks. The solutions to previous homework sets will be discussed in regular tutorial sessions (once a week, according to the official schedule).

EVALUATION

The evaluation of the course, both in first and second call, will be based on the following sections:

A) Final exam.
B) Continuous evaluation: Based on the work developed by the students in relation to exercises and problems presented and/or delivered or follow-up tests.

The final grade will be obtained from the higher of the following two grades:

1) Weighted average of the grades of sections A (70%) and B (30%), provided that in A a minimum of between 3.5 and 4 points out of 10 is obtained (the specific criteria for each group will be communicated at the beginning of the course).

2) Grade for section A (out of 10).

REFERENCES

Basic

- L. N. Hand y J. D. Finch, Analytical Mechanics, Cambridge University Press, 1998.
- C. Gignoux y B. Silvestre-Brac, Mécanique, EDP Sciencies, Université Joseph Fourier, Grenoble, 2002.
- D. W. Hogg, Special Relativity, http://cosmo.nyu.edu/hogg/sr/.

Additional

- J. V. José y E. J. Saletan, Classical Dynamics: a contemporary approach, Cambridge University Press, 1998
- T. W. B. Kibble y F. H. Berkshire, Classical Mechanics, Imperial College Press, 2004.
- J. R. Taylor, Classical Mechanics, University Sciencie Books, 2005.
- H. Goldstein, C. Poole y J. Safko, Classical Mechanics, Addison-Wesley Publishing Company, 2002.
- H. Müller-Kirsten, Classical Mechanics and Relativity, World Scientific Publishing Company, 2008.
- H. Iro, A Modern Approach to Classical Mechanics, World Scientific Publishing Company, 2002.
- I. Percival y D. Richards, Introduction to Dynamics, Cambridge University Press, 1982.
- Rañada, Dinámica Clásica, Alianza Universidad Textos, Madrid, 1994.
- G. L. Baker y J. P. Gollub, Chaotic Dynamics, Cambridge University Press, 1990
- C. Gignoux y B. Silvestre-Brac, Problèmes corrigés de Mécanique et résumés de cours, EDP Sciencies, Université Joseph Fourier, Grenoble, 2004.
- Lim Yung-kuo (Editor), Problems and Solutions on Mechanics, World Scientific Publiching Co. Pte. Ltd., 1994.