COURSE DATA

Data Subject	
Code	34247
Name	Mathematical methods I
Cycle	Grade
ECTS Credits	6.0
Academic year	2021 - 2022

Study (s)

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

Subject-matter

Degree	Subject-matter	Character
1105 - Degree in Physics	8 - Mathematical methods	Obligatory
1929 - D.D. in Physics-Chemistry	2 - Segundo Curso (Obligatorio)	Obligatory

Coordination

Name	Department
OLMO ALBA, GONZALO	185 - Theoretical Physics
VICENTE VACAS, MANUEL JOSE	185 - Theoretical Physics

SUMMARY

- Objectives: To acquire knowledge of mathematics concerning the resolution of differential equations necessary for studies in Physics.

- Relationship with other previous, concurrent and future subjects: As the subject is instrumental, all the subjects of the degree require concepts and techniques contained in the subject.

It is advisable to have passed the courses Algebra and Geometry I and II, and Calculus I and II.

- Descriptors: Ordinary Differential Equations. Linear and non linear differential equations. Systems of differential equations. Solution of differential equations with power series. Special Functions. Introduction to partial differential equations.

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 essential to have previous knowledge on the following topics
(at the level of the Algebra and Geometry I and II, and Calculus I and II courses) :

1. Differential calculus in one and several variables.
2. Integration in one and several variables.
3. Numerical sequences and series.
4. Power Series.
5. Linear Systems.
6. Vector Spaces.
7. Matrices and determinants, linear operators, eigenvalues and eigenvectors.

OUTCOMES

1105 - Degree in Physics

- 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.
- 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.
- 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

1. Qualitative and quantitative analysis of differential equations and their solutions

2. Understanding the origin and solving, through various techniques, some of the basic equations of Physics

3. Knowing the methods to solve systems of differential equations based on matrix theory and the concepts of vector space, eigenvectors and eigenvalues.

4. Knowing the special functions and orthogonal polynomials commonly used in physics and their properties. Generating functions

DESCRIPTION OF CONTENTS

1. Ordinary differential equations of first order

Definitions and notation. Family of curves. Ordinary differential equations of first order. Separable equations. Exact equations. Integrating factor. Reducible order.

2. Ordinary differential equations of higher order

Linear and nonlinear differential equations. Linearly independent solutions. Wronskian. Initial and boundary conditions. Solution of linear differential equations with constant coefficients: undetermined coefficients, variation of parameters, reduction of order. Case Study: Euler equation, ...

3. Systems of equations with constant coefficients

Concept and examples. Resolution by substitution or elimination. Matrix Methods: homogeneous and non-homogeneous systems. Qualitative resolution of nonlinear equation systems: equilibrium points and the phase diagram. Autonomous systems.

4. Solutions of differential equations with powers series

Introduction and review of concepts. Classification of points: regular and singular points (Regular and irregular). Solution around an ordinary point. Solution around a regular singular point: Frobenius theorem. Examples.

5. Special Functions

Hypergeometric function. Solutions Legendre differential equation. Generating function and recurrence and orthogonality relations. Rodrigues formula. Extension to associated Legendre, Hermite and Laguerre polynomials. Bessel functions and spherical harmonics.

6. Partial Differential Equations

Definition and classification. Initial and boundary conditions. Diffusion equation. Resolution by separation of variables. Wave equation. Examples: spherical harmonics. Stationary problems.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	45,00	100
Tutorials	15,00	100
Development of individual work	30,00	0
Study and independent work	60,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

The methodology of the course will be: 4 hours per week, of which 3 hours per week correspond to theoretical and practical classes and 1 hour weekly tutoring class in small groups.

In theoretical and practical classes, the teacher will develop the content of the subject, with emphasis on the resolution of issues, problems and applications. Part of the contents, demonstrations and / or applications may be left as work for tutoring classes.

Tutoring classes will be devoted to solve and / or to discuss the problems of the collection that previously the teacher shall make available to students either on paper or via the virtual classroom, corresponding to each chapter of the syllabus explained in theoretical and practical classes. Also to resolve theoretical issues assigned to students and assess the presentation and results obtained. The collection of problems, in general, contains generic problems, which will be resolved in theoretical and practical classes and others that need to be addressed by students. Doubts or resolution of the latter part of the classes will be held in tutoring classes.

EVALUATION

Assessment system:

1) Written examinations: one part will assess the understanding of the conceptual and theoretical formalism of the subject, both through theoretical, conceptual and numerical questions or in the consideration of simple particular cases. Another part will assess the ability to apply the formalism to solve problems and the student critical capacity regarding the obtained results. In both parts, it will be valued a proper and adequate reasoning and justification.

2) Continuous assessment: assessment of work and problems presented by students, issues proposed and discussed in class, oral presentation of problems solved or any other method involving interaction between teachers and students.

The qualifications of the subject will be obtained from the corresponding exam score and the qualification of the tutorship work (weighted with 70% and 30% respectively) or only with the exam grade, if the student has not participated in the work in tutorials, according to the formula max (0.7 * E + 0.3 * T, E) where E is the exam score and T is the tutoring score, both over 10.

Note that the exam (E) must always be 4.0 or higher (out of 10) to be able to compensate with the one of tutorials and to obtain a qualification of approved (5).

Subject to compliance with the compensation criteria established for this purpose, the grading for this course could be averaged with other courses on the same subject, in order to obtain the grade required for approval.

REFERENCES

Basic

- R. Kent Nagle, E.B. Staff, Fundamentos de ecuaciones Diferenciales, Addison Wesley Iberoamericana.
- K.F. Riley, M.P. Hobson, S.J. Bence, Mathematical methods for physics and engineering: A comprehensive guide, Cambridge University Press
- D.G. Zill, M.R. Cullen, Ecuaciones diferenciales con problemas de valor en la frontera. Paraninfo Thomson Learning 2001.

Additional

- Martin Braun. Ecuaciones diferenciales y sus aplicaciones. Grupo Editorial Iberoamérica
- E.D. Rainville. Ecuaciones Diferenciales. Prentice Hall Hispanoamericana
- E.D. Rainville, ``Intermediate Differential Equations''. Chelsea Publishing Co.
- C.H. Edwards Jr. y David E. Penney, ``Ecuaciones Diferenciales Elementales''. Prentice Hall.
- A. Jeffrey. Handbook of mathematical formulas and integrals. Academic Press
- F. Ayres, ``Ecuaciones Diferenciales''. McGraw-Hill. Serie Schaum.
- R. Bronson, ``Ecuaciones Diferenciales Modernas''. McGraw-Hill. Serie Schaum.
- S. J. Farlow, Partial Differential Equations for Scientists and Engineers

ADDENDUM COVID-19

This addendum will only be activated if the health situation requires so and with the prior agreement of the Governing Council

In case that health situation requires blended teaching, the teaching model approved by the Academic Degree Committee on July 23, 2020 will be adopted.
For lectures this model consist of 50% student attendance in the classroom, while the rest of students attend the class in streaming broadcast. Two groups will be set with alternate days attendance to the classroom in order to guarantee 50% of teaching hours attendance for all students.
The rest of the teaching activities (laboratories, computer rooms, tutorials) will have a 100% attendance.
If a total reduction in attendance is necessary, classes will be broadcast by synchronous videoconference at their regular schedule, along the period determined by the Health Authority.