COURSE DATA

DATA SUBJECT

Code: 34255
Name: Electromagnetism I
Cycle: Undergraduate Studies
ECTS Credits: 6
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	3	First quarter
1929 - Double Degree Program in Physics and Chemistry	Facultat de Física	3	First quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1105 - Degree in Physics	Electromagnetism	COMPULSORY
1928 - Double Degree Program Physics-Mathematics	Tercer Curso (Obligatorio)	COMPULSORY
1929 - Double Degree Program in Physics and Chemistry	Tercer Curso (Obligatorio)	COMPULSORY

COORDINATION

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SUMMARY

"Electromagnetism I" is a subject matter imparted along the first term of the academic year. This subject is a part of the more general matter "Electromagnetism" and has 6 ECTS credits (about 45 hours of theoretical and practical presential classes, 15 hours of presential supervised work and 90 hours of home work).

The descriptors for this course are: electrostatic and magnetostatic fields in vacuum, electromagnetic induction phenomena, Maxwell equations, electromagnetic waves in vacuum and potential theory.

This course aims to give an overview of the electromagnetic interaction in vacuum, constructed as a field theory. This implies the need for a precise definition of the electric and magnetic fields as vector fields, which can be done from the Helmholtz theorem. Thereby the knowledge of the divergence and the curl of the field is established as necessary to define the field uniquely. That is precisely what the Maxwell equations of the electromagnetic field express. The obtention of these equations from the experimental study of the basic interactions between charges and currents provides an experimental basis to the theory.

The relationship of this subject with other subjects in the degree in Physics is evident through his own content. The consequences of the electromagnetic interaction are studied in the subject Mechanics. The analysis of wave solution of Maxwell's equations requires the knowledge obtained in Oscillations and Waves and constitutes the basis of Optics. The mathematical tools needed to solve Maxwell's equations are studied in different Mathematical Methods subjects. Finally, the study of the electromagnetic interaction in vacuum and its consequences directly affect the subject Laboratory of Electromagnetism.

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 recommended to have completed subjects of the first and second year, especially: Physics, Calculus, Mechanics, Oscillations and Waves and Mathematical Methods.

COMPETENCES / LEARNING OUTCOMES

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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. Introduction to electromagnetism

1.1. The Electromagnetic interaction in Physics
1.2. Charges and currents.
1.3. The charge conservation. Continuity equation.
1.4. Unequivocal determination of a vector field. The Helmholtz Theorem.

2. The electrostatic field

2.1. Introduction.
2.2. Coulomb's Law.
2.3. Electric field. Divergence and curl of electrostatic fields.
2.4. Gauss's Theorem.
2.5. Electrostatic potential.

3. Multipolar expansion of electrostatic potential

3.1. Introduction.
3.2. Multipolar expansion of the electrostatic field.
3.3. The potential and electric field of a dipole
3.4. Electric dipole distributions.

4. The electrostatic potential

4.1. Introduction. Conductors in electrostatics.
4.2. Unicity Theorems.
4.3. The method of images.
4.4. Separation of variables.

5. The magnetostatic field

5.1. Introduction.
5.2. Ampère's Law.
5.3. Magnetic field. Divergence and curl of the magnetic field.
5.4. Ampère's Theorem.
5.5. Potential vector.
5.6. The Lorentz Force Law.

6. Multipolar expansion of the magnetic potential

6.1. Introduction.
6.2. Multipolar expansion of the magnetic potential.
6.3. The potential and field of a magnetic dipole.
6.4. Magnetic dipole distributions.

7. Electromagnetic induction

7.1. Introduction.

7.2. Electromotive force.
7.3. Induction for a moving circuit.
7.4. Faraday's Law of the electromagnetic induction.
7.5. Induction coefficients.

8. Maxwell's equations. Electromagnetic waves

8.1. Introduction.
8.2. Displacement current.
8.3. Maxwell's equations in vacuum.
8.4. Wave equations.
8.5. Plane electromagnetic waves.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Tutorials	15,00
Theory	45,00
Total hours	**60,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	35,00
Preparation of lessons	30,00
Preparation for assessment activities	17,00
Resolution of case studies	8,00
Total hours	**90,00**

TEACHING METHODOLOGY

The course will consist of: (i) Theoretical and practical classes, (ii) tutorized work.

In the classes of type (i), basic theoretical contents as well as model problems that illustrate this theory will be taught (with a proportionality of about 2 h theory/1 h problems). PowerPoint presentations could be used, including graphs, drawings, videos and animations, combined with discussions/presentations on the blackboard. These slides will be available to students in the Virtual Classroom.

Additionally, in these types of classes, simple practical demonstrations may be presented, including particularly relevant examples, applets, simulations, etc. that allow the illustration of some of the phenomena explained. Likewise, the student will be encouraged and guided to expand the content received in this type of class through recommended readings.

In the classes of type (ii) different problems will be set and solved in small groups by means of a tutorial system. Students will be asked in the same classroom to explain the resolution of problems not solved in the theoretical classes, or to hand over solved problems provided in advance as homework.

EVALUATION

The assesment 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 and/or 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 exercices and problems presented by students, questions proposed and discussed in class, oral presentation of problems solved or any other method that involves that involves a better understanding of the student's academic progress.

3) Assessment criteria: The mark to pass the subject will be equal to or greater than 5/10 points, which will be obtained: (a) Written exam (75%), (b) Continuous evaluation (25%), (c) Final grade: it will be the highest to consider, the grade of the written exam and the continuous evaluation, or only the note of the written exam.

Evaluation criteria are the same in both the first and the second call.

COMMENTS: Subject to compliance with the compensation criteria established for this purpose, note this course can be averaged with other others belonging to the same matter, so as to pass the course.

REFERENCES

Basic

- Griffiths, D.J., *Introduction to Electrodynamics*. Prentice Hall, 1989.

- Reitz, J.R., Milford, F.J., Christy, R.W., *Fundamentos de la Teoría Electromagnética*. Addison-Wesley Iberoamericana, 1986.

Additional

- Wangness, R.K., *Campos electromagnéticos*. Limusa, 1983.

- Feynman, R., Leighton, R.B., Sands, M., *Física (Volumen II: electromagnetismo y materia)*. Addison- Wesley Iberoamericana, 1987.

- Vanderlinde, J., *Classical electromagnetic theory*, John Wiley & Sons, 1993.

- Marshall,S., Dubroff ,R.and Skitek,G., *Electromagnetismo, conceptos y aplicaciones*. Prentice Hall, 1997.