COURSE DATA

Data Subject	
Code	34255
Name	Electromagnetism I
Cycle	Grade
ECTS Credits	6.0
Academic year	2022 - 2023

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	3	First term
1929 - Double Degree Program in Physics and Chemistry	Double Degree Program Physics and Chemistry	3	First term

Subject-matter

Degree	Subject-matter	Character
1105 - Degree in Physics	11 - Electromagnetism	Obligatory
1928 - Double Degree Program Physics-Mathematics	3 - Tercer Curso (Obligatorio)	Obligatory
1929 - Double Degree Program in Physics and Chemistry	3 - Tercer Curso (Obligatorio)	Obligatory

Coordination

Name	Department
GIMENO MARTINEZ, BENITO	175 - Applied Physics and Electromagnetism
MARTINEZ TOMAS, M DEL CARMEN	175 - Applied Physics and Electromagnetism
MUÑOZ SANJOSE, VICENTE	175 - Applied Physics and Electromagnetism

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

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

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.
- 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)

At the end of the course the students should have competences that allow them to:

- Know how to express mathematically three-dimensional distributions of electrical charge, two-dimensional lines and point charges and electric currents, and know how to use the continuity equation in order to make a charge balance.

- Understand the importance of the divergence and rotor concepts related with a vector field in the frame of the Helmholtz theorem.

- Learn to deduce the divergence and rotor of the electrostatic field from Coulomb's law.

- Know the basic procedures for determining the electrostatic field from a charge distribution (direct integration of the field, Gauss theorem, integration of the potential).

- Understand the importance of the multipole expansion of the electrostatic potential and the concepts of point charge and dipole. Knowing how to calculate the electrostatic field created by distributions of electric dipoles.

- Know the specific techniques of problem solving through the electrostatic potential theory and know how to apply imaging methods and separation of variables in simple cases.

- Learn to deduce the divergence and rotor of the magnetostatic field from Ampere's Law interaction between filiform circuits.

- Know the basic procedures for determining the magnetostatic field from a current distribution (direct integration of the field, Ampere's theorem, integration of the vector potential).

- Know the law of the Lorentz force and its effect on point charges and currents, as well as its relationship with induction phenomena.

- Understand the importance of the multipole expansion of the potential vector and the concept of dipole. Knowing how to calculate the magnetostatic field distributions of magnetic dipole distributions.

- Understand the laws of electromagnetic induction and know its effects on simple problems related with moving circuits and time-dependent fields.

- Understand the importance of introducing the concept of displacement current and know how to illustrate it with simple examples.

- Know the differential formulation of the Maxwell equations and know how to solve them in the simplest cases, such as in the case of plane waves in a vacuum.

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

ACTIVITY	Hours	% To be attended
Theory classes	45,00	100
Tutorials	15,00	100
Attendance at events and external activities	0,00	0
Development of group work	0,00	0
Development of individual work	0,00	0
Study and independent work	35,00	0
Preparation of evaluation activities	15,00	0
Preparing lectures	10,00	0
Preparation of practical classes and problem	20,00	0
Resolution of case studies	8,00	0
Resolution of online questionnaires	2,00	0
TOTAL	**150,00**	

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. (4) To make an average, the note of any part (theory, problems or continuous assessment) must be at least 4/10 points.

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
- Pomer, F., Electromagnetisme Bàsic. Universitat de València, 1993.

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.