

**COURSE DATA****DATA SUBJECT****Code:** 34256**Name:** Electromagnetism II**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	Second quarter
1928 - Double Degree Program Physics-Mathematics	Facultat de Ciències Matemàtiques	3	Second quarter
1929 - Double Degree Program in Physics and Chemistry	Facultat de Física	3	Second 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

The subject Electromagnetism II is a subject matter of the third year of the Bachelor's Degree in Physics and the Double Degrees in Physics-Chemistry and in Physics-Mathematics, being imparted along the second 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 matter, Maxwell's equations and electromagnetic waves in matter, the electromagnetic energy and momentum, circuit theory of localized and distributed parameters, waveguides and cavities.



This course aims to give an overview of the electromagnetic interaction in matter, presented as a field theory. This implies the need of an introduction to the properties of polarization and magnetization of matter. The electromagnetic energy and momentum will be also studied, being formulated from conservation principles in the frame of a purely electromagnetic interaction. Finally, another object of study will be the circuit theory of localized and distributed parameters, the guided propagation of electromagnetic waves and the solution of the Maxwell equations in cavities.

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 electromagnetic interaction with matter and its consequences directly affects the subject Laboratory of Electromagnetism and other subjects that will be studied later as the Solid State Physics and Semiconductor Physics. As well, circuit theory and guided conduction will constitute the necessary basis to study other subjects such as Electromagnetic Waves and Electronics.

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. To have completed the subject Electromagnetism I.

COMPETENCES / LEARNING OUTCOMES

1105 - Degree in Physics

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. Electric and magnetic fields in material media

- 1.1. Introduction.
- 1.2. Microscopic and macroscopic fields.
- 1.3. Conductive media. Electrical conductivity.
- 1.4. Dielectric media. Polarization. Vector D .
- 1.5. Magnetic media. Magnetization. Vector H .
- 1.6. Maxwell's equations in material media.



2. Electromagnetic waves in material media

- 2.1. The equation of waves in material media.
- 2.2. Monochromatic plane electromagnetic waves.
- 2.3. Electromagnetic waves in a dielectric medium with losses.
- 2.4. Electromagnetic waves in a good conductor. Skin effect.

3. The energy of static fields

- 3.1. Energy of a set of point charges in vacuum.
- 3.2. Energy of a charge distribution.
- 3.3. Energy in the presence of dielectric media. Polarization energy.
- 3.4. Energy of a set of filiform currents in vacuum.
- 3.5. Energy of a current distribution. Magnetization energy.
- 3.6. Energy and forces.

4. Energy and electromagnetic moments

- 4.1. Poynting's theorem in differential form. Poynting vector.
- 4.2. Poynting's theorem in integral form.
- 4.3. Poynting's theorem for harmonic fields.
- 4.4. The linear electromagnetic moment. Maxwell's tensor.
- 4.5. The angular momentum of the fields. The Feynman paradox.

5. Electromagnetic wave guidance

- 5.1. Maxwell's equations in a system with translational symmetry. Types of modes.
- 5.2. Transmission lines.
- 5.3. Waveguides.
- 5.4. Resonant cavities. Quality factor.

6. Fundamentals of electric circuit theory

- 6.1. Distribution of currents in steady state.
- 6.2. Alternating current circuits.
- 6.3. AC power.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
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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	15,00
Resolution of case studies	10,00
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 type 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 assessment system is as follows:

1) Written examinations: One part (50%) 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 (50%) 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. To pass the subject, it is necessary to obtain at least a mark of 4/10 in the evaluation of the written examinations.

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 a better understanding of the student's academic progress. A regular and participative attendance to the classes is necessary to have the right to a continuous assessment mark. In case of complying with the aforementioned minimum grade and having participated in the continuous evaluation, a weighted grade will be obtained: written examinations (75%) and continuous assessment (25%).

The final grade will be obtained as the maximum between said weighted grade and the grade obtained only of the consideration of written exams. The qualification needed to pass the subject is 5 out of 10.

These evaluation criteria will be applied in the same way in both calls.

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

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.
- Sánchez, F., Sanchez, J.L., Sancho, M., Santamaría, T., *Fundamentos de Electromagnetismo*. Síntesis, Madrid, 2000.
- Vanderlinde, J., *Classical electromagnetic theory*, John Wiley & Sons, 1993.
- Marshall, S., Dubroff, R. and Skitek, G., *Electromagnetismo, conceptos y aplicaciones*. Prentice Hall, 1997.