Electromagnetic Fields and Waves

Code: 107847
ECTS Credits: 9

2025/2026

Degree	Type	Year
Electronic Engineering for Telecommunications	FB	1
Telecommunication Systems Engineering	FB	1

Contact

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

It is highly recommended that the student:

- Understands the basic operations with vectors: addition, subtraction, dot product, and cross product.
- Is able to differentiate single-variable functions.
- Knows how to integrate single-variable functions using a table of integrals.
- Has some knowledge of line, surface, and volume integrals, as well as partial derivatives.

Objectives and Contextualisation

- Understand the physical foundations of the electromagnetic field in its different manifestations: electrostatics, magnetostatics, and electromagnetic induction, both in vacuum and in material media.
- Develop skills in the use of mathematical tools such as vector analysis to describe and analyze continuous physical fields.

- Interpret and apply the fundamental laws of electromagnetism, culminating in the unified formulation of Maxwell's equations and their implications for the propagation of electromagnetic waves in a vacuum.

- Introduce the basic concepts of oscillations and waves from a mechanistic perspective, as a foundation for the subsequent study of radiation and electromagnetic wave guiding, which will be addressed in the course *Radiation and Guided Waves*.

Learning Outcomes

1. KM12 (Knowledge) Define the basic concepts in the general laws of fields and waves and electromagnetism applied to telecommunications.
2. KM12 (Knowledge) Define the basic concepts of the general laws of fields and waves and electromagnetism applied to telecommunications.
3. KM13 (Knowledge) Define the propagation and transmission mechanisms of electromagnetic and acoustic waves, as well as their corresponding emitting and receiving devices.
4. KM13 (Knowledge) Define the mechanisms for the propagation and transmission of electromagnetic and acoustic waves, as well as their corresponding emitting and receiving devices.
5. KM14 (Knowledge) Identify the fundamental principles of classical dynamics and thermodynamics.
6. KM14 (Knowledge) Identify the fundamental principles of classical dynamics and thermodynamics.
7. SM09 (Skill) Apply the basic concepts of the general laws of mechanics, thermodynamics, fields and waves, and electromagnetism to solve engineering problems.
8. SM09 (Skill) Apply the basic concepts about the general laws of mechanics, thermodynamics, fields and waves and electromagnetism to solve engineering problems.
9. SM11 (Skill) Apply the principles of classical dynamics and thermodynamics to solve engineering problems.
10. SM11 (Skill) Apply the principles of classical dynamics and thermodynamics to solve engineering problems.

Content

1. Oscillations

- Simple harmonic motion
- Energy of a simple harmonic oscillator
- Damped oscillations
- Forced oscillations. Resonance

2. Waves

- Simple wave motion
- Traveling waves
- Harmonic waves
- Superposition and interference of harmonic waves
- Energy transmitted by waves
- Standing waves on strings

- Doppler effect

3. Vector Analysis
    - Dot product and cross product
    - Scalar and vector fields
    - Gradient, divergence, and curl of vector fields
    - Laplacian
    - Line integral, circulation, and flux of a vector field
    - Gauss's theorem and Stokes's theorem
4. Electrostatics in Vacuum and in Material Media
    - Electric charge and Coulomb's law
    - Electric field
    - Gauss's law. Divergence of the electric field
    - Electric potential
    - Electric dipole. Electric polarization. Dielectric media. Displacement vector
5. Magnetostatics in Vacuum and in Material Media
    - Electric current. Continuity equation. Ohm's law. Joule's law
    - Magnetic force
    - Lorentz force
    - Magnetic induction: Biot-Savart law
    - Ampère's law
    - Magnetic potential
    - Magnetic dipole. Magnetic polarization. Magnetic media. Magnetic intensity
6. Electromagnetic Induction
    - Faraday's law. Lenz's law. Curl of the electric field
    - Self-inductance. Mutual inductance
    - Magnetic energy
7. Maxwell's Equations
    - Generalization of Ampère's law. Curl of the magnetic field
    - Maxwell's equations
    - Electromagnetic waves
8. Fundamentals of Thermodynamics

- Temperature and heat
- Entropy

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lecture sessions	48	1.92	KM12, KM12, KM13, KM14, SM09, SM11
Problem sessions	22	0.88	KM12, KM12, KM13, KM14, SM09, SM11
Type: Supervised			
Problem-solving sessions	2	0.08	SM09, SM09, SM11
Type: Autonomous			
Individual study	139	5.56	KM13, KM13, KM14, SM09, SM11

- Lecture classes, aimed at facilitating the learning of the fundamental concepts of the syllabus, which can also be found in the recommended bibliography.
- Problem-solving classes, in which exercises related to the content covered in the lectures will be solved, with the objective of consolidating knowledge and developing problem-solving skills.
- Individual or small-group tutorials, aimed at resolving specific doubts that may arise during personal study, as well as reinforcing the acquisition of the specific and transversal competencies associated with the course.
- Supervised group problem-solving sessions, in which students will work collaboratively under the supervision of the teaching staff to apply the knowledge acquired in solving practical cases. These activities will be assessed and will contribute to the final grade of the course.

  Note: 15 minutes of one class session will be reserved, within the schedule established by the centre or degree programme, for students to complete the surveys evaluating the teaching performance and the course/module.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Guided problem-solving session 1	10%	1	0.04	KM12, SM09

Guided problem-solving session 2	10%	1	0.04	KM12, KM13, KM14, SM09, SM11
Individual written test 1	10%	2	0.08	KM14, SM11
Individual written test 2	10%	2	0.08	KM14, SM11
Individual written test 3	30%	4	0.16	KM12, SM09
Individual written test 4	30%	4	0.16	KM12, KM13, KM14, SM09, SM11

a) Scheduled assessment process and activities

Assessment in this course is based on two main types of activities:

Individual midterm exams: Four written tests, including both theoretical questions and problem-solving. Two exams will take place during the first semester (worth 1 point each), and two during the second semester (worth 3 points each), for a maximum total of 8 points.

Instructor-led group problem-solving sessions: Two activities, one per semester, involving collaborative problem-solving under the supervision of the teaching staff. Each session will be worth 1 point, for a total of 2 points.

The final grade will be the sum of all scores, with no minimum required for each activity. A minimum of 5 out of 10 points is required to pass the course.

b) Assessment schedule

The dates of the midterm exams and the instructor-led sessions will be published on the Virtual Campus at the beginning of the semester. Any changes will also be communicated through this platform in advance, as it is the official communication channel between faculty and students.

c) Resit process

A comprehensive written resit exam covering the entire course content is planned, with a maximum score of 10 points, on the date established by the School of Engineering.

Only students who have obtained a minimum score of 3.5 points in at least one midterm exam in each semester will be allowed to take the resit exam.

d) Grade review procedure

Grade reviews will be carried out exclusively for the "midterm exam" assessment type. The date, time, and location of the review session will be announced in advance. Activities of the "problem-solving session" type are considered non-recoverable according to the School of Engineering's regulations.

e) Special grading situations

"Not assessable": This grade will be assigned to any student who does not attend any of the midterm exams.

Distinctions with honors: These may be awarded to students who achieve a final grade of 9.0 or higher, up to 5% of total enrolled students. Active participation during the course may be taken into account by the teaching staff when awarding honors.

f) Student misconduct, copying and plagiarism

Without prejudice to other disciplinary measures deemed appropriate and in accordance with current academic regulations, any misconduct by a student that could affect the assessment of an activity will result in a score of zero. Activities penalized in this way will not be eligible for resit. If passing the course requires passing such an activity, the course will be automatically failed with no opportunity for recovery during the same academic year.

Such misconduct includes, but is not limited to:

- total or partial copying of any assessed activity;
- allowing others to copy;
- submitting a group project not entirely completed by the group members;
- submitting materials authored by a third party as one's own, including translations or adaptations;
- having communication devices accessible during assessment activities;
- speaking with classmates during assessment activities;
- copying or attempting to copy from other students during assessments;
- using or attempting to use unauthorized materials during assessments.

g) Assessment of repeating students

From the second enrollment onwards, it will not be necessary to have participated in a minimum number of continuous assessment activities to take the resit exam.

h) Single assessment

This course does not include a single-assessment option.

i) Use of artificial intelligence (AI) technologies

The use of artificial intelligence (AI) technologies is not permitted at any stage of this course. Any assignment including content generated by AI will be considered a breach of academic integrity and may lead to partial or total penalties in the grade for that activity, or more serious sanctions in severe cases.

Bibliography

Basic bibliography

1. Tipler, P. A., & Mosca, G. (2010). *Physics for Scientists and Engineers* (Vols. 1 & 2, 6th ed.). Reverté.
2. Gettys, W. E., Keller, F. J., & Skove, M. J. (1991). *Classical and Modern Physics* (Vols. 1 & 2, 1st ed.). McGraw-Hill.
3. Giancoli, D. C. (2008-2009). *Physics for Scientists and Engineers* (Vols. 1 & 2, 6th ed.). Pearson Education.

Complementary bibliography

4. Feynman, R. P., Leighton, R. B., & Sands, M. L. (1963-1965). *The Feynman Lectures on Physics* (Vols. 1 & 2). Addison-Wesley.

Software

No specific software is required.

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	311	Catalan/Spanish	annual	morning-mixed
(PAUL) Classroom practices	312	Catalan/Spanish	annual	morning-mixed
(PAUL) Classroom practices	331	Catalan/Spanish	annual	morning-mixed
(PAUL) Classroom practices	332	Catalan/Spanish	annual	morning-mixed
(TE) Theory	31	Catalan/Spanish	annual	morning-mixed
(TE) Theory	33	Catalan/Spanish	annual	morning-mixed