UAB
Universitat Autònoma de Barcelona

Electromagnetic Fields and Waves

2026/2027

Code: 107847
Credits: 9

Degree programme	Type	Course
Electronic Engineering for Telecommunications	FB	1
Telecommunication Systems Engineering	FB	1

Contact lecturer

Name : Gerard Zamora Gonzalez

Email : gerard.zamora@uab.cat

Teaching staff

Marc Porti Pujal

Javier Martin Martinez

Jordi Bonache Albacete

Group languages

You can consult this information at the end of the 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

- Understand the physical foundations of electrostatics and magnetostatics, both in vacuum and in material media, as well as the phenomena of electromagnetic induction, culminating in the unified formulation of electromagnetism through Maxwell's equations.
- Develop proficiency in the use of mathematical tools, such as vector analysis, to describe and analyse continuous physical fields.
- Interpret and apply the fundamental laws of electromagnetism to analyse and solve problems involving electric and magnetic fields, as well as understand the implications of Maxwell's equations for the propagation of electromagnetic waves.
- Introduce the fundamental concepts of oscillations and waves from a mechanistic perspective, providing the foundation for the subsequent study of electromagnetic radiation and waveguiding, which will be

addressed in the course *Radiation and Guided Waves*.

Learning outcomes

Electronic Engineering for Telecommunications

- CU098 (Solve problems related to the propagation and transmission mechanisms of electromagnetic and acoustic waves, as well as their corresponding transmitting and receiving devices, in accordance with the regulatory and technical standards established in the sector.) Solve problems related to the propagation and transmission mechanisms of electromagnetic and acoustic waves, as well as their corresponding transmitting and receiving devices, in accordance with the regulatory and technical standards established in the sector.
- KU106 (Define the basic concepts in the general laws of fields and waves and electromagnetism applied to telecommunications.) Define the basic concepts in the general laws of fields and waves and electromagnetism applied to telecommunications.
- KU107 (Define the propagation and transmission mechanisms of electromagnetic and acoustic waves, as well as their corresponding emitting and receiving devices.) Define the propagation and transmission mechanisms of electromagnetic and acoustic waves, as well as their corresponding emitting and receiving devices.
- KU108 (Identify the fundamental principles of classical dynamics and thermodynamics.) Identify the fundamental principles of classical dynamics and thermodynamics.
- SU113 (Apply the basic concepts of the general laws of mechanics, thermodynamics, fields and waves, and electromagnetism to solve engineering problems.) Apply the basic concepts of the general laws of mechanics, thermodynamics, fields and waves, and electromagnetism to solve engineering problems.
- SU114 (Calculate the fundamental parameters of a communication system related to wave transmission and reception.) Calculate the fundamental parameters of a communication system related to wave transmission and reception.
- SU115 (Apply the principles of classical dynamics and thermodynamics to solve engineering problems.) Apply the principles of classical dynamics and thermodynamics to solve engineering problems.

Telecommunication Systems Engineering

- CU098 (Solve problems related to the propagation and transmission mechanisms of electromagnetic and acoustic waves, as well as their corresponding transmitting and receiving devices, in accordance with the regulatory and technical standards established in the sector.) Solve problems related to the propagation and transmission mechanisms of electromagnetic and acoustic waves, as well as their corresponding transmitting and receiving devices, in accordance with the regulatory and technical standards established in the sector.
- KU106 (Define the basic concepts in the general laws of fields and waves and electromagnetism applied to telecommunications.) Define the basic concepts in the general laws of fields and waves and electromagnetism applied to telecommunications.
- KU107 (Define the propagation and transmission mechanisms of electromagnetic and acoustic waves, as well as their corresponding emitting and receiving devices.) Define the propagation and transmission mechanisms of electromagnetic and acoustic waves, as well as their corresponding emitting and receiving devices.
- KU108 (Identify the fundamental principles of classical dynamics and thermodynamics.) Identify the fundamental principles of classical dynamics and thermodynamics.
- SU113 (Apply the basic concepts of the general laws of mechanics, thermodynamics, fields and waves, and electromagnetism to solve engineering problems.) Apply the basic concepts of the general laws of mechanics, thermodynamics, fields and waves, and electromagnetism to solve engineering problems.
- SU114 (Calculate the fundamental parameters of a communication system related to wave transmission and reception.) Calculate the fundamental parameters of a communication system related to wave transmission and reception.
- SU115 (Apply the principles of classical dynamics and thermodynamics to solve engineering problems.) Apply the principles of classical dynamics and thermodynamics to solve engineering problems.

Contents

1. Oscillations

- Simple harmonic motion
- Harmonic motion and circular motion
- Energy of simple harmonic motion
- Damped oscillations
- Forced oscillations and resonance

2. Waves

- Simple wave motion
- Traveling waves
- Harmonic waves
- Interference of harmonic waves
- Wave packets and group velocity
- Energy transmitted by waves
- Standing waves on strings
- The Doppler effect

3. Vector Analysis

- Vector algebra
- Line integral of a vector field
- Gradient of a scalar field
- Flux of a vector field
- Divergence of a vector field
- Gauss's theorem
- Circulation of a vector field
- Curl of a vector field
- Stokes' theorem
- Helmholtz's theorem

4. Electrostatics in Vacuum and in Material Media

- Electric charge and Coulomb's law
- Electric field
- Gauss's law
- Electric potential
- Electrostatic potential energy
- Conductors
- Dielectrics
- Parallel-plate capacitors

5. Magnetostatics in Vacuum and in Material Media

- Electric current
- Continuity equation
- Ohm's law
- Lorentz force
- Magnetic force on a current
- Magnetic induction: Biot-Savart law
- Ampère's law
- Gauss's law for magnetism
- Vector potential
- Magnetism in matter

6. Electromagnetic Induction

- Faraday's law

- Alternating-current generators and electric motors
- Inductance

7. Maxwell's Equations

- Ampère-Maxwell law
- The charging capacitor
- General form of Maxwell's equations
- Propagation of electromagnetic waves

8. Fundamentals of Thermodynamics

- Temperature and heat
- Entropy

Learning activities and methodology

Title	Hours	ECTS	Learning outcomes
Individual study	149	5.96	CU098, SU113, SU114, SU115
Guided collaborative exam practice	2	0.08	CU098, KU106, KU107, KU108, SU113, SU114, SU115
Problem sessions	22	0.88	CU098, SU113, SU114, SU115
Lecture sessions	46	1.84	CU098, KU106, KU107, KU108, SU113, SU114, SU115

- 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.
- Collaborative exam simulation sessions in small groups (2-3 students), during which students will work together to complete a representative test covering the course content studied up to that point. Afterwards, the test will be reviewed and discussed collectively in class to provide immediate feedback, identify concepts requiring further reinforcement, familiarise students with the expected level of the course assessments, and promote discussion and critical reasoning about both theoretical and practical concepts. These sessions are intended solely for formative purposes and will not be assessed.

The course incorporates cooperative learning and formative assessment methodologies through supervised collaborative problem-solving sessions and collaborative mock examinations in small groups, with immediate feedback aimed at promoting continuous learning and consolidating the fundamental concepts.

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

Continuous assessment activities

Title	Weight	Hours	ECTS	Learning outcomes
Individual written test 1	35%	2	0.08	CU098, KU107, KU108, SU113, SU114, SU115

Individual written test 2	49%	2	0.08	CU098, KU106, KU107, KU108, SU113, SU114, SU115
Guided problem-solving session	16%	2	0.08	CU098, SU113, SU114, SU115

a) Scheduled assessment process and activities

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

1. Individual midterm examinations: two written examinations consisting of theoretical questions and problem-solving exercises. One examination will be held during the first semester and will contribute up to 3.5 points towards the final course grade, while the other will be held during the second semester and will contribute up to 4.9 points. Together, these assessment activities will contribute a maximum of 8.4 points towards the final course grade.

2. Supervised group problem-solving session: one collaborative problem-solving activity supervised by the teaching staff. It will take place during the second semester and will account for up to 1.6 points.

The final grade will be the sum of the marks obtained in all assessment activities. To pass the course, students must obtain a minimum mark of 3.5 out of 10 in each of the two written examinations, as well as 3.5 out of 10 in the overall set of theoretical questions in each examination. If a student does not pass the course because they have not achieved the minimum required mark in either of the written examinations, the final grade recorded in the academic transcript will be the lower of 4.5 or the weighted average of all assessment activities.

b) Assessment schedule

The dates of the midterm examinations and supervised sessions will be published on the Virtual Campus at the beginning of the semester. Any changes will also be announced through this platform sufficiently in advance, as it constitutes the official communication channel between the teaching staff and students.

There is a protocol for requesting the rescheduling of assessment activities in the cases stablished in the Assessment Criteria and Guidelines of the School of Engineering.

c) Resit process

A comprehensive written examination covering the entire course will be offered, with a maximum mark of 10 points, on the date established by the School of Engineering. If a student takes the resit examination, the final course grade will be the mark obtained in that examination. Students may take the resit examination provided that they have completed assessment activities accounting for at least two thirds of the final grade for the course.

d) Grade review procedure

Grade reviews will only be available for activities classified as midterm examinations. The date, time and location of the review session will be announced in advance.

Activities classified as problem-solving sessions are not recoverable in accordance with the regulations of the School of Engineering.

e) Special grading situations

Not Assessed: this grade will be assigned to students who do not sit any of the midterm examinations.

Honours Distinction: may be awarded to students obtaining a final grade of 9.0 or higher, up to a maximum of 5% of the students enrolled in the course. Active participation throughout the course may be taken into consideration by the teaching staff when awarding this distinction.

f) Student misconduct, copying and plagiarism

Without prejudice to any additional disciplinary measures that may be imposed, and in accordance with the current academic regulations, any misconduct that may lead to an alteration of the grade of an assessment

activity will result in a grade of zero.

Assessment activities graded in this way are not recoverable. If passing any such activity is required to pass the course, the student will automatically fail the course, with no possibility of resitting it during the same academic year.

Such misconduct includes, but is not limited to:

- copying all or part of a practical exercise, report or any other assessment activity;
- allowing another student to copy;
- submitting group work that has not been entirely carried out by the members of the group;
- submitting as one's own work materials produced by third parties, including translations or adaptations;
- having communication devices (such as mobile phones, smartwatches, etc.) accessible during individual assessment activities;
- talking to classmates during individual assessment activities;
- copying or attempting to copy from other students during assessment activities;
- using or attempting to use unauthorised materials during assessment activities unless expressly authorised.

g) Single assessment

This course does not include a single-assessment option.

h) Use of artificial intelligence (AI) technologies

The use of Artificial Intelligence (AI) technologies is not permitted during any assessment activity in this course, including written examinations and supervised activities. Any unauthorised use of these technologies will be considered a breach of academic integrity and will entail the consequences established by the current academic regulations.

Bibliography

Basic bibliography

1. Tipler, P. A., & Mosca, G. (2010). *Física para la ciencia y la tecnología* (Vols. 1 y 2, 6.ª ed.). Editorial Reverté.
2. Feynman, R. P., Leighton, R. B., & Sands, M. L. (1963-1965). *The Feynman Lectures on Physics* (Vols. 1 & 2). Addison-Wesley.
3. Gettys, W. E., Keller, F. J., & Skove, M. J. (1991). *Física clásica y moderna* (Vols. 1 y 2, 1.ª ed.). McGraw-Hill.
4. Giancoli, D. C. (2008-2009). *Física para ciencias e ingeniería* (Vols. 1 y 2, 6.ª ed.). Pearson Educación.

Supplementary bibliography

1. J. Costa Quintana y F. López Aguilar (2012). *Interacción electromagnética: Teoría clásica.* Editorial Reverté.

Software

No specific software is required.

Course groups and languages

The information provided is provisional until November 30. After this date, you will be able to consult the language of each group through this link. To access the information, you will need to enter the course CODE

Type of

teaching	Group	Language	Semester	Shift
(TE) Theory	31	Catalan/Spanish	annual	morning-mixed
(TE) Theory	33	Catalan/Spanish	annual	morning-mixed
(TE) Theory	51	Catalan/Spanish	annual	morning-mixed
(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
(PAUL) Classroom practices	511	Catalan/Spanish	annual	morning-mixed