Bachelor in Physics
(Academic Year 2024-25)

Electromagnetism II		Code	800502	Year	2nd	Sem.	2nd
Module	General Core	**Topic**	Classical Physics			**Character**	Obligatory

	Total	Theory	Exercises
ECTS Credits	6	3.6	2.4
Semester hours	55	31	24

Learning Objectives (according to the Degree's Verification Document)

- To get basic knowledge of electromagnetism radiation emission mechanisms.
- To get knowledge of electromagnetic field energy and momentum concepts.
- To understand the relation between electromagnetism and theory of relativity.

Brief description of contents

Electromagnetic potentials. Electromagnetic waves. Radiant systems. Relativist formulation.

Prerequisites

Electromagnetism I. Mathematics, Calculus, Algebra.

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Theory/Problems – Schedule and Teaching Staff

Group	Lecture Room	Day	Time	Professor	Period/ Dates	Hours	T/E	Dept.
B	4A	Tu, Th	12:00 – 14:00	Oscar Rodríquez de la Fuente	Full term	55	T/E	FM

T: Theory, E: Exercises

Office hours

Group	Professor	Schedule	E-mail	Location
B	Oscar Rodríguez de la Fuente	L, X. 12:00-14:00 +2h On line	oscar.rodriguez@fis.ucm.es	02.218.0

Syllabus

1.- Fundamentals

Phasor representation. Differential, integral and phasor formulation of Maxwell equations. Constitutive relationships. Boundary conditions. Electromagnetic potentials. Wave equation. Quasi-static approach.

2.- Boundary problems: static fields

The boundary problem in electrostatics. Uniqueness theorem. Reciprocity theorem. Method of images. Separation of variables.

3.- Monochromatic plane waves

Harmonic fields. Monochromatic plane waves. Propagation in dielectrics and conductors. Reflection by conductive surfaces. Energy and moment of electromagnetic waves. Radiation pressure.

4.- Guided waves

Confinement in propagating electromagnetic waves. Rectangular waveguides. TE and TM Modes. TEM modes. Resonant cavities.

5.- Radiation

Retarded potentials. Liénard-Wiechert potentials. Velocity and acceleration fields. Accelerated charges in free space: equations of movement, fields. Radiation generated by currents in conductors. Dipole radiation. Radiant systems.

6.- Electromagnetism and relativity

Lorentz transformations. Space-time structure: interval, light cone, invariant. Four-vectors (position, velocity, moment...). Relativistic electrodynamics: four-current. Four-potential. The magnetic field as a relativistic effect. Transformations of the fields. Electromagnetic tensor.

Bibliography

[1] RP Feynman, RB Leighton y M Sands, “The Feynman Lectures on Physics, New Millennium Edition Vol. II: Mainly Electromagnetism and Matter”, Caltech, (2010). https://www.feynmanlectures.caltech.edu/info/

[2] DJ Griffiths, “Introduction to Electrodynamics”, 5ª Ed., Cambridge University Press, (2023).

[3] P Lorrain, D Corson, F Lorrain, “Electromagnetic Fields and Waves”, 3ª Ed., Freeman and Co., (1988).

[4] MH Nayfeh, MK Brussel, “Electricity and Magnetism”, Dover Publications, (2015).

[5] DM Pozar, "Microwave Engineering", 4ª Ed., Wiley, (2021).

[6] JR Reitz, FJ Milford, RW Christy, “Foundations of Electromagnetic Theory”, Addison-Wesley, 4ª Ed., (2008).

[7] MNO Sadiku, “Elements of Electromagnetics”, 3ª Ed. OUP USA, (2000).

[8] F Sánchez, LL Sánchez, M Sancho, J Santamaría, “Fundamentos del Electromagnetismo”, Síntesis, (2000).

[9] RK Wangsness, “Campos Electromagnéticos”, Limusa, (2006).

[10] A Zangwill, “Modern Electrodynamics”. Cambridge University press, (2013).

Online Resources

Course materials will be provided at the Campus Virtual of the UCM.
“Fundamentals of Applied EM”, https://www.youtube.com/channel/UCn-0FOjOLbuSZq7PkJUmzqg

Methodology

The following training activities will be developed:

- Theory lessons (lectures) where most of the main concepts will be explained, including examples and applications.
- Problem-solving practical lessons.

In theory lessons both the board and slides will be used. Sometimes these lessons will be complemented with computer simulations and virtual experiments.

The problems of each lesson will be delivered to the students before their solving in the classroom. Also, briefings and documents of some special subjects will be distributed.

Short tests, solved problems and short classroom seminars will be considered as a part of the continuous assessment.

Evaluation Criteria

Exams	**Weight:**	80%

The grade N_{final} of this part (Exams) will be obtained using the following scores:

- $N_{partial}$: Grade of a mid-course and voluntary exam of the first four topics.
- N_{Ex_final}: Grade of the final exam.

If the student doesn´t make the mid-course exam or its grade is below 5, $N_{Final} = N_{Ex\_final}$.

If not, $N_{Final} = N_{EX\_final} + 2 \cdot N_{partial}/10$, up to a maximum grade of 10.

The final exam will include all the contents of the course, regardless of the grade of the mid-course exam. The exams will include i) a first part containing qualitative and short problems and/or theoretical questions and ii) a second part with problems.

Other Activities	**Weight:**	20%

A maximum of 2 points are granted for seminars and tests to be done during class time, as well as homework deliverables.

Final Mark

If the mark of the final exam (N_{Ex_final}) is equal to or higher than 4 then the final course mark (C_{Final}) will be the highest of the following:

$$C_{Final} = 0.2N_{Other\_activ} + 0.8N_{Final} \quad \text{and} \quad C_{Final} = N_{Final},$$

where N_{Other_activ} is the grade from *Other Activities* and N_{Final} is the grade obtained from the exams (see the notes above).

If N_{Ex_final} is lower than 4 then the final mark will be $C_{Final} = N_{Ex\_final}$, and the subject will be failed.

The June/July exam (extraordinary examination) will consist in a single test of the whole subject. The grade obtained in this exam will be combined with the grades of the rest of the activities, in the same way as in the ordinary examination.