# Bachelor in Physics
## (Academic Year 2022-23)

| 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.



| Coordinator | José Miguel Miranda Pantoja | | Dept. | EMFTEL |
|---|---|---|---|---|
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**Theory/Exercises – Schedule and Teaching Staff**

| Group | Lecture Room | Day | Time | Professor | Period/ Dates | Hours | T/E | Dept. |
|---|---|---|---|---|---|---|---|---|
| B | 4ª | Tu,Th | 12:00-14:00 | Emilio Nogales Díaz | Whole semester | 55 | T&E | FM |

T: Theory, E: Exercises

**Office hours**

| Group | Professor | Schedule | E-mail | Location |
|---|---|---|---|---|
| B | Emilio Nogales Díaz | X, V: 11:30-13:00 | enogales@ucm.es | 211(2ªplanta) |

## 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

**Basic:**

- Wangsness. “Electromagnetic Fields”. Wiley.
- D.J. Griffths. “Introduction to Electrodynamics”. Prentice Hall.
- Jackson. “Classical Electrodynamics”. Wiley
- Reitz, Milford y Christy. “Foundations of Electromagntic Theory”. Pearson.
- Andrew Zangwill. “Modern Electrodynamics”. Cambridge University Press.

**Complementary:**

- F. Sánchez Quesada, L. L. Sánchez Soto, M. Sancho Ruiz y J. Santamaría. “Fundamentos del Electromagnetismo”. Editorial Síntesis.
- Feynman, Leighton y Sands. “Lectures on Physics”, Vol. 2: Electromagnetism and Matter. Addison Wesley

## 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% |
|---|---|---|

Regarding continuous assessment, up to 2 points (in a 0-10 scale) can be obtained with the following activities:

- Short exercises and testsin the Campus Virtual (15%)
- Preparation of short classroom presentations about specific issues on electromagnetism (5%)

## Final Mark

The final course mark (F) 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).

The 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.