# Bachelor in Physics
## (Academic Year 2024-25)

| **Electromagnetism I** | **Code** | 800501 | **Year** | 2nd | **Sem.** | 1st |
|---|---|---|---|---|---|---|
| **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 dominate the basic description of electromagnetic field generation by charges and currents and of the action of the fields on the charges.
- To learn and know how to use Maxwell's equations in their differential and integral form.
- To get knowledge of electromagnetic field energy and momentum concepts.

**Brief description of contents**

Electromagnetic and magnetostatic fields in vacuum and material medium. Time variable fields. Maxwell equations.

**Prerequisites**

Physical Fundamentals I and II. Mathematics, Calculus, Algebra (differential and integral calculus in one and multiple variables, matrices and determinants)



| **Coordinator** | Carlos León Yebra | | **Dept.** | FM |
|---|---|---|---|---|
| | **Room** | 02.109.0 | **e-mail** | carlos.leon@ucm.es |



**Theory/Problems – Schedule and Teaching Staff**

| **Group** | **Lecture Room** | **Day** | **Time** | **Professor** | **Period/ Dates** | **Hours** | **T/E** | **Dept.** |
|---|---|---|---|---|---|---|---|---|
| **B** | 10 | Tu, Th We | 10:30 – 12:00<br>11:00 – 12:00 | María Varela del Arco | Full term | 40 | T/E | FM |
| | | | | Jorge Estrada Álvarez | | 15 | T/E | FM |

T: Theory, E: Exercises

| Office hours | | | | |
|---|---|---|---|---|
| **Group** | **Professor** | **Schedule** | **E-mail** | **Location** |
| **B** | María Varela del Arco | Tu, W, Th 13:00-14:00 +3h On line | mvarela@ucm.es | 03.117.0 |
| | Jorge Estrada Álvarez | M, X: 11.30-13.00 J: 11.00-14.00 On line | jorgestr@ucm.es | 02.204.0 |

## Syllabus

**1.- Scalar & vector fields.** Coordinate systems. Gradient of a scalar field. Circulation and flux of a vector field. Divergence. Gauss' theorem. Curl. Stokes' theorem. Laplacian. Helmholtz theorem. Dirac delta function.

**2.- Electrostatics in vacuum.** Coulomb's law. Electric field & electric potential. Differential & integral formulations of the electrostatic field equations. Gauss' law. Conducting and dielectric matter. Multipole expansion of the potential outside a charge distribution. Electric dipole.

**3.- Electrostatic fields in matter.** Electric polarization, **P**. Polarization bound charges. The electric displacement, **D**. Constitutive relations. Electric susceptibility and permittivity. Boundary conditions on E, D at the boundary between two dielectrics. Electrostatic energy. Electric forces on dielectrics.

**4.- Magnetostatics in vacuum.** Electric current in a conductor. Current density & continuity equation. Ohm's law and electromotive force. Magnetic field, **B**. Biot-Savart law. Ampère's law. Differential & integral formulations of the magnetostatic field equations. The magnetic vector potential. The magnetic scalar potential.

**5.- Magnetostatic fields in matter.** Magnetization, **M**. The field produced by magnetized matter. Magnetization bound currents and magnetic charges. General form of Ampère's law: **H** vector field. Constitutive relations. Magnetic susceptibility. Boundary conditions on **B**, **H**.

**6.- Electromagnetic fields & Maxwell equations.** Faraday-Lenz law. Mutual induction and self-induction. Magnetostatic energy. Magnetic forces. Displacement current. Maxwell equations. Electromagnetic energy. Poynting vector. Poynting's theorem. Electromagnetic moment.

## Bibliography

**Basic:**


- Griffiths, D.J.: *Introduction to Electrodynamics* (3rd. Edition). Prentice Hall International (1999).


**Complementary:**


- Reitz, J. R.; Milford, F. J. y Christy, R. W.: *Foundations of Electromagnetic Theory*. 4th Ed. Addison-Wesley (1993).
- Wangsness, R. K.: *Campos Electromagnetic Fields*. 2nd Ed. Wiley (1986).
- Zangwill, A.: *Modern Electrodynamics.* Cambridge University Press (2013).
- Sánchez Quesada, F., Sánchez Soto, L. L., Sancho Ruiz, M., y Santamaría, J.: *Fundamentos de Electromagnetismo*. Síntesis, Madrid (2000).
- Purcell, E.M. & D. J. Morin: *Electricity and Magnetism* 3rd Ed. Cambridge University Press (2013).
- Fleisch, D.: *A student's guide to Maxwell's equations*. Cambridge University Press, Nueva York (2008).
- Lorrain, P y Courson, D. R.: *Electromagnetic Fields & Waves*. 2nd Ed. W. H Freeman (1970).
- Pramanik, A.: *Electromagnetism. Problems with Solutions*. PHI Learning Private, Ltd. Nueva

Delhi, 2012.
- López, E. y Núñez, F.: *100 problemas de Electromagnetismo*. Alianza Editorial, Madrid (1997).
- López Rodríguez, V.: *Problemas resueltos de Electromagnetismo*. Fundación Areces, Madrid (2003).
- Fernandez, A.G.: *Problemas de campos electromagnéticos*. McGraw-Hill (Serie Schaum), Madrid (2005).

## Online Resources

Relevant course materials will be made available online through the Virtual Campus

## Methodology

Classroom activities will include both theory lessons (where the main concepts of the subject will be explained, including examples and applications) and practical classes of problems and directed activities.

Both the blackboard and computer projections will be used in theory classes. Occasionally, these lessons will be complemented by classroom experiences, or computer simulations and virtual practices, etc. These basic activities will aim at illustrating the studied subject.

Students will receive the problem sheets in advance. As part of the continuous assessment, students will have to periodically deliver resolved problems and / or specific assignments. In addition, students will be provided with self-assessment forms and / or exams of previous calls.

## Evaluation Criteria

| **Exams** | **Weight:** | 80% |
|---|---|---|

The final exam will consist of a part of theoretical-conceptual-practical questions and a second part of problems (similar to those solved in class). For the problems part a theory book can be used, freely chosen by the student.

| **Other Activities** | **Weight:** | 20% |
|---|---|---|

Occasional tests will be carried out in class. Also, students will turn in homework assignments individually, consisting of problems, exercises, etc.

### Final Mark

The final grade CF will be given by the formula:

CF = max{0.2*A + 0.8*E, E} where E is the final exam score and A the final score of other activities.