Bachelor in Physics
(Academic Year 2021-22)

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	54	29.5	24.5

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	Bianchi Méndez Martín		Dept.	FM
	Room	125	e-mail	bianchi@fis.ucm.es

Theory/Exercises – 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 11:00-12:00	María Varela del Arco	Whole semester	40	T/E	FM
				Norbert Nemes	Whole semester	14	T/E	

T: Theory, E: Exercises

Office hours

Group	Professor	Schedule	E-mail	Location
B	María Varela del Arco	Mo, Tu, We 13:00-14:00	mvarela@ucm.es	Room 117, 3rd floor, East.
	Norbert Nemes	Mo.17:00-18:30, Fr :. 9:00-10:30 online whole course	nmnemes@fis.ucm.es	Room 121, 3rd floor, East.

+ 3 h. online

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

On-campus teaching 100% (Scenario 0)

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.

Semi-online teaching (Scenario 1)

Partially in-person teaching will be adapted to the general UCM indications according to the relevant health situation, for example by dividing through each group into subgroups that will alternate between in-person and telematic attendance (e.g. choosing modality A, B, or a mode suggested by the circumstances). Each teacher will decide the way to organize his/her group with respect to partially in-person teaching, as well as the evaluation activities, ensuring that lectures and relevant materials can be followed partially online. This methodology will be continuously reviewed and will be adapted to the particular teaching needs of each group.

Online teaching (Scenario 2)

Online teaching will be adapted as much as possible to the indications of the UCM, according to the relevant health situation at the time. Each teacher will decide how to organize the activities of their group for online teaching, as well as the evaluation activities.

Teachers will publicize the appropriate procedure for following the teaching online, through the Campus Virtual for example. The relevant classes or materials will be prepared for online learning, which may include procedures such as streaming the classes synchronously, making the classes available for viewing asynchronously, or others, at the discretion of each teacher. This methodology will be continuously evaluated and adapted to the particular teaching needs of each group.

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. Students will be allowed to write their homework, exams and class exercises both in English and in Spanish. Only students who have attended at least 80% of the classes, except duly justified absences, can obtain a grade in this section.

Final Mark

For in-person or partially in-person teaching, 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.

In scenario 2 (fully online): Both the evaluation and the relative weights of the continuous evaluation and the final exam will adapted, according to the criteria of each lecturer, to the online methodology followed and to the demands of the health situation. Professors will inform each group as they see appropriate, e.g. through the Campus Virtual.