Universitat Autònoma de Barcelona

2020/2021

Electricity and Magnetism

Code: 100138
ECTS Credits: 6

Degree	Type	Year	Semester
2500097 Physics	FB	1	2

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

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Use of Languages

Principal working language: spanish (spa)

Some groups entirely in English: No

Some groups entirely in Catalan: No

Some groups entirely in Spanish: No

Teachers

Javier Rodríguez Viejo

Marta González Silveira

Prerequisites

To take this course it is recommended that the student has the knowledge of mathematics and physics of the baccalaureate.

Objectives and Contextualisation

In this subject we intend to teach in a qualitative and quantitative way how to reason to understand aspects of the world around us and develop skills in solving problems. These skills will be developed in the framework of electrostatics, magnetostatics, electrical circuits and electromagnetism. We will make special emphasis on explaining the phenomena associated with electrostatics (resting charges) and the magnetostatics (stationary currents). The electromagnetic force, one of the four fundamental forces, has many applications in the world around us, so understanding it is key. We will see the most relevant applications.

Through an inductive process, we will arrive at the four Maxwell equations, which form the basis of the classical theory of electromagnetism, and we will see how electromagnetic waves are a consequence. Electromagnetism has a significant mathematical load. As there is a specific subject of electromagnetism to the second year and the subject is part of a General Physics course, our description will be more qualitative, enhancing the conceptual aspects.

At the end of this course students should be trained to:

Describe the vectorial nature of the electric field and its relationship with the scalar potential.

Understand Gauss's law, its generality and relationship with Coulomb's law and calculate electric fields using both laws.

Describe the vector nature of a static magnetic field and be able to calculate the magnetic field using the law of Biot and Savart and / or the law of Ampere.

Relate electric and magnetic fields in the application domain of Faraday-Lenz law.

Know and understand Maxwell's equations in an integral way.

Understand the operation of devices that make use of electromagnetismfor its operation, especially the different types of circuits in both direct and alternating current.

Competences

- Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
- Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Develop strategies for analysis, synthesis and communication that allow the concepts of physics to be transmitted in educational and dissemination-based contexts
- Formulate and address physical problems identifying the most relevant principles and using approximations, if necessary, to reach a solution that must be presented, specifying assumptions and approximations
- Know the fundamentals of the main areas of physics and understand them
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project

Learning Outcomes

1. Analyse and interpret the main experiments related to basic physics.
2. Analyse certain open questions in contemporary physics and explain them clearly.
3. Apply the laws of electromagnetism to the operation of devices and circuits.
4. Calculate electric and magnetic fields using the laws of Coulomb, Gauss, Biot & Savart and Ampere.
5. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
6. Contrast the sharpness of mathematical results with margins of error in experimental observations.
7. Describe magnetic fields.
8. Describe the Maxwell equations in integral form.
9. Describe the electric field vector and its relationship with scalar potential.
10. Explain the explicit or implicit code of practice of one's own area of knowledge.
11. Identify situations in which a change or improvement is needed.
12. Interact across diverse areas of basic physics.
13. Make mathematical rigor compatible with approximate physical modelling.
14. Relate the basic concepts of physics with scientific, industrial and everyday subjects.
15. Select good variables and carry out correct simplifications.
16. Use complex numbers.
17. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
18. Use differential and integral calculus.
19. Use linear transformations and matrix calculus.

20. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
21. Carry out academic work independently using bibliography (especially in English), databases and through collaboration with other professionals

Content

1.- Electrostatics

1.1 Law of Coulomb. Principle of Superposition

1.2 Electric field and field lines.

1.3 Discrete and continuous distributions of electric charge.

1.4 Law of Gauss

1.5 Electric potential

1.6 Electrostatic energy

1.7 Electric field in conductors

1.8 Capacity and capacitors. Association of capacitors.

2.- Electric current

2.1 Intensity and current density

2.2 Law of Ohm. Electric conductivity.

2.3 Resistance association. Joule effect

2.4 Batteries

2.5 DC circuits. Kirchhoff Rules

2.6 Charging and discharging a capacitor

3.- Magnetostatic

3.1 Magnetic force Lorentz Force

3.2 Moment about current turns. Hall effect.

3.3 Law of Biot-Savart.

3.4 Force between circuits: Ampere law

3.5 Magnetism of matter.

4.- Electromagnetism

4.1 Electromagnetic induction. Law of Faraday-Lenz

4.2 Inductance. Magnetic field energy

4.3 Generalized Ampere Law.

4.4 Eqs. of Maxwell.

4.5 Electromagnetic wave equation.

4.6 Electromagnetism and relativity

5.- Alternating current circuits

5.1 Effective value. fasores

5.2 Circuits without generator (LC, RLC)

5.3 Circuits with generator (RLC)

Methodology

This course offers a diversified education, with the different training activities described below. The work hours that are specified for each training activity correspond to an average student. Naturally, not all students need the same time to learn concepts and carry out certain activities, so the distribution of time should be understood as guidance. In this subject, the active student participation is a key tool to enhance learning beyond simple repetition and memorization. We believe it is very important that the student prepares the class before attending, since undoubtedly this active participation will improve your learning. To facilitate this active attitude, at the beginning of the course students are given a table with the calendar of the different sessions, indicating, each day, the type of training activity what will take place and its content. The students will know the first day that, for example, on May 5 they will be explained in a master class the Faraday-Lenz law.

Directed training activities:

Lectures: Classes in which the theory teacher explains the most relevant concepts of each subject. The students will have the transparencies of the master class in pdf format in advance and inside the UAB's virtual campus. In order to make the most of master class sessions, it is very important that the student read before attending each session the material accessible on the network (virtual campus) corresponding to that session, as well as the reference text pages where the concepts of the session are explained. Most lessons will also include conceptual tests.

Learning through conceptual tests (conceptual test learning): These sessions will complement the master classes. They consist in the resolution by students of some tests that are designed in order to better understand the concepts which have been explained in the master class. After thinking individually what is the correct answer, we proceed to a few minutes of discussion among the students and then ask again which option they think is the correct one. The objective of this activity is to help the student to reach the key concepts that have been explained in the master session of the same day, encouraging both the individual reflection and the discussion between peers (peer learning).

Problem solving: Classes in which the problem teacher explains to the students how to solve the type problems of the subject. The teacher will resolve in detail a list of selected problems, and will propose to the students a list of problems that may be delivered optionally.

Group work sessions: In these classes students' active participation will be requested, either by solving problems that the teacher proposes, posing questions, presenting papers, etc.

Supervised training activities: Tutorials: in the hours of attention to the students, the teachers will be available for the consultations of the students who have doubts in any of the subjects of the agenda.

Autonomous training activities: Preparation of master classes: the student must prepare the master classes in advance, consulting both the material available on the virtual campus and the reference bibliography.

Problem solving and delivery of additional problems: the student must solve the problems of the list given by the teachers and the additional ones that the teacher asks of problems or those that the student wants to do on their own to prepare the subject better.

Study and preparation of exams: Personal work of the student to acquire the theoretical concepts of the subject and the abilities for the resolution of problems.

Preparation and delivery of individual works: eventually, the teacher willask the students to perform small individual works, typically within the sessions of group activities.

Contest: the professors will propose to the students the realization ofan experimental work (construction of a device) related to electromagnetism

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Conceptual test learning	2	0.08	
Exercices	16	0.64	
Group activity, seminars and hand outs	6	0.24	
Theory	28	1.12	
Type: Supervised			
Mentoring	3	0.12	
Type: Autonomous			
Contest	4	0.16	
Exam preparation	37	1.48	
Homework	6	0.24	
Problem solving	26	1.04	
pre-reading theory lessons	10	0.4	

Assessment

The final grade is obtained considering the grade of each formative activity according to the weight that has been indicated; that is, using the formula: final grade = evaluation partial content 1 x 0.40 + evaluation partial content 2 x 0.40 + evaluation group activities / seminars x 0.20

To be able to apply this formula, it is necessary that the note (out of 10) of each of the partials is equal to or greater than 4. In the case that in partial 1 or 2 the grade is less than 4, the student must be presented to the repechage either of the whole course, or of the part that has suspended with a grade lower than 4.

If any student, despite having the approved subject, wants to improve the grade, he / she can submit to the repechage to the part he / she wants (partial1, partial2, or the whole course) with the understanding that for the final grade it will be considered the note obtained in the repechage. There is no possibility of improving the grade corresponding to group activities, the problems delivered and the contest.

Important: Due to the new regulations, students must have realized the two partial exams to make the recovery exam.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exam 1	40%	3	0.12	13, 5, 6, 10, 21, 11, 17, 14, 15
Exam 2	40%	3	0.12	1, 4, 13, 9, 14, 12, 20, 18
Final exam	80%	3	0.12	1, 3, 4, 7, 8, 14, 12, 20, 18
Group activity, seminars and hand outs	20%	3	0.12	2, 1, 3, 4, 13, 5, 6, 7, 9, 8, 21, 14, 12, 15, 20, 18, 16, 19

Bibliography

Notes at campus virtual

Tipler y Mosca. Física para la ciencia y la tecnología. Volum 2. Editorial Reverté. 6a Edició, 2010.

Young y Freedman. Física Universitaria. Volum 2. Editorial Addison-Wesley. 12a edició, 2009.