UAB
Universitat Autònoma de Barcelona

Electromagnetism

Code: 100149
ECTS Credits: 10

2024/2025

Degree	Type	Year
2500097 Physics	OB	2

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

It is advisable to have passed the subject Electricity and Magnetism of the first course of Physics.

Objectives and Contextualisation

Have a basic knowledge of the electromagnetic field, from electrostatics and magnetostatics (in vacuum and in material media) to electromagnetic induction and Maxwell's equations.

To be able to calculate various solutions of Maxwell's equations, including electromagnetic waves and their propagation.

Competences

- 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. Correctly handle vector calculus.
2. Describe electrostatic phenomena.
3. Describe magnetostatic phenomena.
4. Describe phenomena that involve time-dependent electromagnetic processes.
5. Formulate and solve mathematical problems concerning electrostatic phenomena.
6. Formulate and solve mathematical problems on electromagnetic phenomena that involve time-dependent processes.
7. Identify situations in which a change or improvement is needed.
8. Solve complex problems of an electromagnetic nature from the establishment of hypotheses that, even being approximate, contain the essence of physics in the original problem.
9. Translate specific physical problems of electromagnetic nature to a mathematical formulation that allows subsequent resolution, either exact or approximate.
10. Transmit, orally and in written format, physical concepts of a certain complexity, making them understandable to non-specialist settings.
11. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
12. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.

Content

1. Vector analysis

Vector algebra.- Gradient.- Divergence.- Theorem of divergence.- Curl.- Stokes theorem.- Helmholtz theorem.- Curvilinear coordinates: gradient, divergence and curl.

2. Electrostatics

Electrical charge and Coulomb law.- Electric field: divergence and curl.- Electrical potential: Poisson and Laplace equations.- Systems of conductors: capacitors.- Energy of a distribution of charges.- Energy of a system of charged conductors .

3. Electrostatics in dielectrics

Multipolar development.- Electric dipole.- Field created by a dielectric.- Vector displacement.- Electrical susceptibility and dielectric constant.- Boundary conditions.- Energy dependence on the field.

4. Magnetostatics

Electric current: Ohm's law.- Continuity equation.- Magnetic induction: Biot and Savart's law.- Force between circuits.- Lorentz force.- Curl of B: Ampere's theorem- Divergence of B.- Potential vector.

5. Magnetism in media

Multipolar development.- Magnetic dipole.- Field created by a magnetic material.- Magnetic strengthH.- Types of magnetic materials.- Boundary conditions.

6. Fields slowly varying

Electromagnetic induction: Faraday's law.- Applications. - Differential expression.- Mutual inductance and selfinductance.- Magnetic energy of coupledcircuits.- Energy based on the field.

7. Electromagnetic fields

Displacement current.- Maxwell's equations.- Boundary conditions.- Scalar potential and vector potential.- Wave equations for V and A.- Retarded potentials.- Electromagnetic energy.

8. Electromagnetic waves

Wave equation for the electromagnetic fields.- Plane wave in a dielectric.- Electromagnetic spectrum.- Plane wave in a conductor.- Wave guides.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problems and practical cases	28	1.12	1, 2, 3, 4, 5, 6, 8, 9, 11
Theory classes	54.75	2.19	1, 2, 3, 4, 5, 6, 9, 11
Type: Supervised			
UAB institutional surveys	0.25	0.01	7
Type: Autonomous			
Study and solution of problems and practical cases	154.5	6.18	1, 2, 3, 4, 5, 6, 8, 9, 10, 11

Theory:

Explanation of the basic contents, with the bibliography and other resources. Explanation of the key aspects, with examples, experimental evidences and, if needed, original works.

Problems:

Guided solution of some basic problems/examples given previously to the students.

Note: 15 minuts will be reseved (in some class) to perform the teaching and subject polls.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Delivery of problems (Dec-Gen)	10%	0.5	0.02	1, 2, 3, 4, 5, 8, 9, 11
Examen Parcial 3 (Jun)	40%	3	0.12	1, 2, 3, 4, 5, 6, 8, 9, 10, 11
Exams recovery	up to 100%	3	0.12	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Partial Exam 2 (Apr-Mai)	30%	3	0.12	1, 2, 3, 4, 5, 6, 8, 9, 11
Partial exam 1 (Jan-Feb)	20%	3	0.12	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12

Deliverable: Students should deliver, in written format, the solucion of some problems that will be announced prevviously.

Partial exams 1-2-3: PTheory questions and solutions of problems (written format) of the part of the sylabus that have already taken at the moment of the exam. Theory questions could be explicit or embeded in some particular problem.

Retaken exam (in the case of having a global qualification less than 5 (over 10)):

- The deliver part cannot be retaken.

- If the average of the qualification in partial 1 and 2 is less that 5 (over 10), there will be a single retaken exam of these parts jointly (50%). There is no option of retake individually these exams.

- If the average of the qualification in partial 3 is less that 5 (over 10), there will be a retaken exam of this part (40%).

- All the retaken exams will be done the same day (the official day)

Single evaluation: Students allowed for the single evaluation, must make 3 exams (the day of the partial 3), corresponding to each of the partial exams. The same day, the written solution of some problems previously announced should be delivered. The retaken process is the same as of the rest of the students.

UAB Regulations: To be able of retaken some exam, the student should have been evaluated of, al least, 2/3 of the total of the evaluation. (In this subject, the student should have been evaluated of the 3rd and the 1st or the 2nd partials (65%)).

UAB Regulations: In the event that the student realizes any irregularity that might lead to a significant variation in the qualification of evaluation activity, he or she will qualify with 0 this evaluation activity, irrespective of the disciplinary process that could be started. If there are several irregularities in the evaluation of the same subject, the final qualification of this subject will be 0.

Any plagiarism (total or partial), copying or attempted copying, letting oneself be copied, etc., in any of the evaluable activities will be considered "irregularities leading to a significant variation in the qualification".

It is imperative that students make their exams in the group in which they are enrolled.

Bibliography

Theory books

1. J. Costa Quintana y F. López Aguilar, *Interacción electromagnética. Teoría clásica*, (Reverté 2007). ISBN: 978-84-291-3058-4.
2. D.J. Griffiths, *Introduction to Electrodynamics*, Fourth Edition, (Cambridge, 2017). ISBN: 978-1-108-42041-9.
3. P. Lorrain y D.R. Corson, *Campos y Ondas Electromagnéticos* (Selecciones Científicas, 1990). ISBN: 84-85021-29-0
4. J. R. Reitz, F. J. Milford, y R. W. Christy, *Fundamentos de la Teoría Electromagnética*, (Addison-Wesley Iberoamericana, 1996). ISBN: 0-201-62592-X
5. R. K. Wangsness, *Electromagnetic fields*, (John Wiley & Sons, 1986, 2nd edition) ISBN: 0-471-81186-6; *Campos electromagnéticos*, (Limusa, 1989).ISBN: 968-18-1316-2.

Problems books

1. E. Benito; *Problemas de campos electromagnéticos*, (AC, 1984) ISBN: 84-7288-007-9
2. J.A. Edminister; *Electromagnetismo* (McGraw-Hill, 1992). ISBN: 970-10-0256-3
3. J.M. De Juana Sardón y M.A. Herrero García; *Electromagnetismo* (Paraninfo 1993) ISBN: 84-283-1992-8
4. E. López Pérez y F. Núñez Cubero; *100 problemas de electromagnetismo*, (AlianzaEditorial, 1997) ISBN: 84-206-8635-2

Software

No specific software is required.

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	1	Catalan	annual	morning-mixed
(PAUL) Classroom practices	2	Catalan	annual	morning-mixed

(TE) Theory	1	Catalan	annual	morning-mixed
(TE) Theory	2	Catalan	annual	morning-mixed