| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Physics Extended** | | | | |
| Subject | Physics Extended | | | |
| Code | V04M141V01104 | | | |
| Study programme | (*)Máster Universitario en Enxeñaría Industrial | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 6 | Optional | 1st | 1st |
| Teaching language | English | | | |
| Department | | | | |
| Coordinator | Fernández Fernández, José Luís<br>López Vázquez, José Carlos | | | |
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| General description | The main goals of Physics Extended are:<br>a) To get a deeper understanding of the physical foundations of engineering, specifically those related to electromagnetic and wave phenomena.<br>b) To introduce the use of mathematical tools, in particular vector analysis and differential equations and their associated boundary value problems, within the framework of problems and models in Physics.<br>c) To combine theoretical education and a practical engineering approach, stressing the relevance of fundamentals to deal with problem analysis and synthesis of solutions in real-life situations.<br>d) To relate the topics in the fundamentals of electromagnetism and wave phenomena to the contents of other more technological subjects included in the curriculum for the Degree.<br><br>The topics of Physics Extended are, essentially, an introduction to wave phenomena in general (three units) and the study of classical electromagnetism using an axiomatic approach employing a mathematical treatment based on differential vector operators (four units). | | | |

| **Skills** | |
|---|---|
| Code | |
| A1 | Knowledge and understanding that provide a basis or opportunity for originality in developing and / or applying ideas, often in a research context. |
| A3 | That students are able to integrate knowledge and handle complexity and formulate judgments based on information that was incomplete or limited, include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments. |
| C7 | CET7. Apply their knowledge and solve problems in new or unfamiliar environments within broader contexts and multidisciplinary environments. |
| C10 | CET10. Possess learning skills that will allow further study of a self-directed or autonomous mode. |

| **Learning outcomes** | |
|---|---|
| Expected results from this subject | Training and Learning Results |
| To know and to understand the physical foundations of mechanical vibrations and waves, as well as of electricity and magnetism | A1<br>A3<br>C7 |
| To know and to be skilled in the application of vector analysis and differential equations of mathematical physics, as problem solving tools within the framework of fundamentals of physics | A1<br>A3<br>C7 |

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|---|---|
| To be able to establish efficient strategies and procedures for solving problems in fundamentals of physics related to industrial technologies | A1<br>A3<br>C7 |
| To be able to implement specific solutions in the laboratory to experimental problems in fundamentals of physics | A1<br>A3<br>C7<br>C10 |

**Contents**

| Topic | |
|---|---|
| I.1. WAVE MOTION | 1.1. Wave phenomena<br>1.2. Fundamental characteristics of waves<br>1.3. The wave equation<br>1.4. Plane waves<br>1.5. Wavefront and wavevector<br>1.6. Cylindrical and spherical waves<br>1.7. Longitudinal and transverse waves<br>1.8. Huygens' principle<br>1.9. Reflection and refraction of waves |
| I.2. MECHANICAL WAVES | 2.1. The nature of mechanical waves<br>2.2. Longitudinal waves in thin rods<br>2.3. Longitudinal waves in springs<br>2.4. Transverse waves in strings<br>2.5. Power flow and intensity of a wave<br>2.6. Longitudinal waves in fluids |
| I.3. DESCRIPTION OF PHYSICAL QUANTITIES BY MEANS OF VECTOR ANALYSIS | 3.1. Differential of arc of a curve<br>3.2. Scalar fields<br>3.3. Directional derivative<br>3.4. Gradient<br>3.5. Vector fields<br>3.6. Flux of a vector field<br>3.7. Solenoidal fields<br>3.8. Divergence of a vector field<br>3.9. Ostrogradski-Gauss' theorem or divergence theorem<br>3.10. Divergence of a solenoidal field<br>3.11. Circulation of a vector field<br>3.12. Rotation or curl of a vector field<br>3.13. Stokes' theorem<br>3.14. Conservative fields |
| II.1. GENERAL EQUATIONS OF ELECTROMAGNETISM | 1.1. Definition of electric and magnetic fields<br>1.2. Field sources: macroscopic electric charges and currents<br>1.3. Relations among fields E and B and their sources: Maxwell's equations<br>1.4. Free charge<br>1.5. Polarization charge<br>1.6. Electric current<br>1.7. Polarization current<br>1.8. Magnetization current<br>1.9. Maxwell's equations as a function of fields E, D, B, and H<br>1.10. Boundary conditions for electromagnetic fields<br>1.11. Electrodynamic potentials<br>1.12. The energy law of the electromagnetic field |
| II.2. TIME-INDEPENDENT FIELDS: ELECTROSTATICS, STEADY ELECTRIC CURRENT AND MAGNETOSTATICS | 2.1. Fundamental equations of electrostatics<br>2.2. Electric dipole<br>2.3. Fundamental equations for steady electric current<br>2.4. Equations including media properties<br>2.5. Electrical resistance<br>2.6. Joule's law<br>2.7. Electromotive forces and generators<br>2.8. Potential distribution in a resistor<br>2.9. Fundamental equations of magnetostatics<br>2.10. Equations including media properties<br>2.11. Magnetic forces<br>2.12. Magnetic circuit<br>2.13. Magnetic dipole |

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|---|---|
| II.3. ELECTROMAGNETIC INDUCTION AND QUASISTATIC FIELDS | 3.1. Electromagnetism in moving media<br>3.2. Galilean transformation of electric and magnetic fields<br>3.3. Electromotive force around a circuit<br>3.4. Faraday's law of electromagnetic induction<br>3.5. Definition of quasistatic fields<br>3.6. Self-inductance and mutual inductance<br>3.7. Magnetic energy |
| II.4. ELECTROMAGNETIC WAVES | 4.1. Wave equations for fields E and H<br>4.2. E.M. monochromatic plane waves in lossless media<br>4.3. E.M. monochromatic plane waves in lossy media<br>4.4. Incidence of a plane wave on an interface between two perfect dielectrics<br>4.5. Incidence of a plane wave on an interface between a perfect dielectric and a conductor |
| III.1 LABS: STRUCTURED ACTIVITY SESSIONS | 1.1 Structured activity sessions:<br>- Experimental data processing (approximate quantities, measurement of physical magnitudes, error estimation)<br>- Adequate operation with basic measurement instruments (flex-meter, micrometer, multimeter (analog and digital), oscilloscope)<br>- Laboratory experiments with mechanical or electromagnetic waves (emission and reception of ultrasonic waves, microwaves or light waves, standing waves along one direction, Michelson interferometer) |
| III.2 LABS: UNSTRUCTURED ACTIVITY (OPEN LAB) SESSIONS | 2.1. Unstructured activity (open lab) sessions:<br>- A practical problem, formulated with basic initial data, will be assigned to each working team. Then, under the teacher's supervision, each team must analyze the problem, select a possible solution and carry it out in the lab<br>- For the open lab problems, a diversity of topics and experimental techniques are considered within the field of wave and electromagnetic phenomena, in particular, electric current conduction and electromagnetic induction in quasistatic regime<br>- As a reference, some open lab problems that can be proposed are: measuring the electric field on a weakly conducting sheet, numerical solution of the Laplace equation, measuring the self-inductance of a coil or a solenoid, measuring the mutual inductance of two coils or two solenoids<br>- As an option, the open lab sessions may be replaced by a well-documented piece of work reporting some topic/technique/process/device related to science or technology where wave or electromagnetic phenomena play an essential role. The report must include a model of the problem, clearly identifying the relevant quantities and physical laws |

## Planning

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Lecturing | 20 | 30 | 50 |
| Problem solving | 9 | 33 | 42 |
| Laboratory practical | 18 | 18 | 36 |
| Problem and/or exercise solving | 2 | 0 | 2 |
| Essay questions exam | 2 | 0 | 2 |
| Report of practices, practicum and external practices | 0 | 18 | 18 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

| | Description |
|---|---|
| Lecturing | The main topics of the subject are introduced by the teacher using projected presentations and the chalkboard, emphasizing the theoretical basis and fundamentals and stressing the critical or key points. Occasionally, demonstrative experiments or audiovisual material may be employed |
| Problem solving | Academic problems related to the topics of the subject are formulated and worked out at the chalkboard by the teacher or the students. By practicing standard schemes, formulas or algorithms and by analyzing the results, the student must develop adequate skills to be able to obtain the correct solution to the problem on his/her own at the end of the course |
| Laboratory practical | Activities for applying the knowledge to particular situations and for developing basic and procedural skills related to the subject. These activities will be held in specific rooms with specialized equipment (laboratories and computer rooms) |

## Personalized assistance

| Methodologies | Description |
|---|---|
| Lecturing | In tutoring hours |
| Problem solving | In tutoring hours |
| Laboratory practical | In tutoring hours |

**Assessment**

| | Description | Qualification | Training and Learning Results | |
|---|---|---|---|---|
| Problem and/or exercise solving | Test in which the student must solve a series of problems and / or exercises in a time / conditions set by the teacher | 40 | A1<br>A3 | C7<br>C10 |
| Essay questions exam | Test that includes open questions on a topic. Students should develop, relate, organize and present knowledge on the subject in an argued response | 50 | A1<br>A3 | C7 |
| Report of practices, practicum and external practices | Each team should write a report on the activities carried out. The report must include the tasks and procedures developed, the results obtained or the observations taken, as well as a detailed description of the data processing and analysis | 10 | A1<br>A3 | C7<br>C10 |

**Other comments on the Evaluation**

**1. CONTINUOUS ASSESSMENT**

**CONTINUOUS ASSESSMENT TESTS (40%)**

- Mark A0 (20%) will be obtained from essay-questions exams on topics of Parts I and II

- Mark L0 (20%) will be obtained from a problem-solving exam on topics of Part III.1 (10%) and from the open lab report (or the topic report) corresponding to Part III.2 (10%). Only students that have regularly attended the lab sessions can obtain mark L0

**FINAL EXAM (60%)**

- To be held in the December-January call

- Mark T1 (30%) will be obtained from an essay-questions exam on topics of Parts I and II

- Mark P1 (30%) will be obtained from a problem-solving exam on topics of Parts I and II

**GLOBAL MARK**

- The global mark G1 is obtained as

G1 = T1 + P1 + L0 + A0

- To pass the course, a student must obtain a global mark G1 equal to or higher than 5

**2. END-OF-TERM ASSESSMENT**

**EXAM THAT REPLACES CONTINUOUS ASSESSMENT TESTS (40%)**

- To be held on the same date as the final exam in the December-January call

- Mark A1 (20%) will be obtained from essay-questions exams on topics of Parts I and II

- Mark L1 (20%) will be obtained from a problem-solving exam on topics of Part III.1

**GLOBAL MARK**

- In this case the global mark G1 is obtained as

G1 = T1 + P1 + L1 + A1

- To pass the course, a student must obtain a global mark G1 equal to or higher than 5

- A student that has previously obtained marks L0 or A0 (or both) can choose between:

a) answering the exam(s) corresponding to mark L1 and/or mark A1, in such a way that the new mark L1 replaces L0 and/or the new mark A1 replaces A0

b) maintaining mark L0 and/or mark A0 instead of taking the exam(s) corresponding to mark L1 and/or mark A1, respectively

**3. ASSESSMENT IN THE SECOND CALL (JUNE-JULY)**

**FINAL EXAM (60%)**

- To be held in the June-July call

- Mark T2 (30%) will be obtained from an essay-questions exam on topics of Parts I and II

- Mark P2 (30%) will be obtained from a problem-solving exam on topics of Parts I and II

**EXAM THAT REPLACES CONTINUOUS ASSESSMENT TESTS (40%)**

- To be held on the same date as the final exam in the June-July call

- Mark A2 (20%) will be obtained from essay-questions exams on topics of Parts I and II

- Mark L2 (20%) will be obtained from a problem-solving exam on topics of Part III.1

**GLOBAL MARK**

- In this case the global mark G2 is obtained as

G2 = T2 + P2 + L2 + A2

- To pass the course, a student must obtain a global mark G2 equal to or higher than 5

- A student that has previously obtained marks L0, L1, A0 or A1 can choose between:

a) answering the exam(s) corresponding to mark L2 and/or mark A2, in such a way that the new mark L2 and/or the new mark A2 will replace the marks of the same type (L0 or L1 and/or A0 or A1, respectively)

b) maintaining the most recent marks of each type (L0 or L1 and/or A0 or A1) instead of taking the exam(s) corresponding to mark L2 and/or mark A2, respectively

**4. NOTATION FOR MARKS**

- L = the latest mark from L0, L1 and L2

- A = the latest mark from A0, A1 and A2

- T = T1 in December-January call (1st edition) or T2 in June-July call (2nd edition)

- P = P1 in December-January call (1st edition) or P2 in June-July call (2nd edition)

- G = G1 in December-January call (1st edition) or G2 in June-July call (2nd edition)

- In either of the calls the global mark G isobtained as

G = T + P + L + A

- To pass the course, a student must obtain a global mark G equal to or higher than 5

**5. SUPPLEMENTARY ASSESSMENT RULES**

- Presentation of DNI or any other identification document is compulsory during tests and exams

- Students should not have access to or use any electronic device during the tests and exams, unless specifically authorised. The mere act of taking an unauthorised electronic device into the examination room will result in the student failing the subject in the present academic year and the global mark will be "suspenso (0.0)"

- The tests and exams will be jointly set and assessed by the teaching team of the subject

- The global mark for students not attending the final exam will be "non presentado"

- The dates for the final exams at each call will be assigned by the board of directors of the School of Industrial Engineering (E.E.I.)

- The exams corresponding to the end-of-degree call, as well as any exam held on dates and at times other than those times stated by the E.E.I. for official exams, could have a different format from the one described above. Nevertheless, each mark (L, A, T and P) will hold its value to calculate the global mark G

- The date and times for the revision (of marks and the results of tests and exams) will be announced in advance. Revision at any other time will only be possible if a justifiable reason for non-attendance is documented

**6. ETHICAL COMMITMENT**

Every student is expected to behave in an appropriate ethical manner. Should unethical conduct be detected (copying, plagiarism, utilisation of unauthorised electronic devices, or others), the student will be considered not to have fulfilled the necessary requirements to pass the subject. In this case, the global mark in the present academic year will be "suspenso (0.0)"

## Sources of information

### Basic Bibliography


Fernández, José L. , Pérez-Amor, Mariano J., **Guía para la resolución de problemas de electromagnetismo. Compendio de teoría**, Reverté, 2012

Fernández, José L. , Pérez-Amor, Mariano J., **Guía para la resolución de problemas de electromagnetismo. Problemas resueltos**, Reverté, 2012

Alonso, M y Finn, E. J., **Física**, Addison-Wesley Iberoamericana, 2000

Alonso, M and Finn, E. J., **Physics**, Pearson, 1992


### Complementary Bibliography


Spiegel, M. R., **Análisis vectorial**, McGraw-Hill, serie Schaum, 2011

Cheng, D. K., **Fundamentos de electromagnetismo para ingeniería**, Addison-Wesley, 1997

Edminister, J. A., **Electromagnetismo**, McGraw-Hill, serie Schaum, 1992

Bronshtein, I. N., **Manual de matemáticas para ingenieros y estudiantes**, MIR 1982, MIR-Rubiños 1993

Spiegel, M. R., **Fórmulas y tablas de matemática aplicada**, McGraw-Hill, serie Schaum, 2014

Spiegel, M. R., **Schaum's Outline of Vector Analysis**, McGraw-Hill, Schaum's Outline Series, 2009

Cheng, D. K., **Fundamentals of Engineering Electromagnetics**, Prentice Hall 1993, Pearson 2014

Edminister, J. A., Nahvi, M., **Schaum's Outline of Electromagnetics**, McGraw-Hill, Schaum's Outline Series, 2013

Bronshtein, I. N. and Semendyayeb K. A., **Handbook of Mathematics**, Springer, 2007

Spiegel, M. R., Lipschutz, S., Liu J., **Schaum's Outline of Mathematical Handbook of Formulas and Tables**, McGraw-Hill, Schaum's Outline Series, 2011


## Recommendations

### Other comments

It is highly recommended to have reviewed the fundamental topics in Physics and Mathematics included within the basic subjects in a standard degree in engineering.
In the event of discrepancy, the Spanish version of this syllabus prevails