**EN 399 PHYSICS 2**
IES Abroad Barcelona

**DESCRIPTION:**
This course provides a comprehensive introduction to the fundamental concepts of electromagnetism, building on prior knowledge of mechanics, basic calculus and vectors (unit vectors, basic vector algebra). It covers the behavior of electric and magnetic fields, their interactions with matter, and the mathematical principles underlying these phenomena. The course is structured into 24 sessions that build upon each other, gradually introducing more complex topics and integrating problem-solving, data analysis, and practical applications.

**CREDITS:** 3 credits

**CONTACT HOURS:** 45 hours

**LANGUAGE OF INSTRUCTION:** English

**INSTRUCTOR:** Pep Mateu

**PREREQUISITES:** Mechanics, basic calculus, basic vector algebra.

**ADDITIONAL COST:** None

**METHOD OF PRESENTATION:**
Each class will consist of explanations of the theoretical concepts needed to understand each module of the course, combined with demonstrations supported by online laboratory software. After each module is completed, several problems will be solved by the students with the instructor's support. Homework assignments will also be given to practice everything learned in the course.

**REQUIRED WORK AND FORM OF ASSESSMENT:**
- Course participation - 10%
- Midterm Exam - 20%
- Final Exam - 30%
- Homework (practice problems – 10 deliveries) - 40%

**Course Participation**
This includes the students' preparation for class, their understanding of assigned readings, their interactions in the classroom with the instructor and their peers, their ability to answer questions posed by the instructor.

**Midterm Exam**
The midterm exam will cover content of up to (and including) 2 sessions before the midterm exam (i.e., the content of 1 session immediately prior to the exam will not be examined). It will be in the style of the homework problems of increasing complexity.

A single A4 sized formula sheet is mandatory (single side, back left blank), which has to be hand-written, including only formulas and no worked-out problems. The formula sheet is expected to be handed in with the exam, and counts as 10% of the achievable grade. This formula sheet will be returned within 2 weeks of the midterm exam, and can be re-used for the final exam.

The midterm exam is closed-book, paper-based, with calculator allowed.

**Final Exam**
The final exam will cover content from the entire course. It will be in the style of the homework problems of increasing complexity, similar to the midterm exam. For the most complex problem there will be a choice between two similarly complex problems, only one of which will need to be solved. Solving both will lead to extra credit.

A single A4 sized formula sheet is mandatory (double sided, e.g., maintaining the midterm formula sheet), which has to be hand-written, including only formulas and no worked-out problems. The formula sheet is expected to be handed in with the exam, and counts as 10% of the achievable grade.

The final exam is closed-book, paper-based, with calculator allowed.

**Homework**
There are 10 homework assignments with example problems, which are intended to prepare for the midterm and final exam. There will be different styles of problems:

- **Comprehension** (similar to exam questions): conceptual questions with free-text answers.
- **Calculation** (similar to exam questions): working out answers to algebra or calculus based questions to electromagnetic problems
- **Numeric** (not on the exams): data analysis and modelling.
- **Interpretation** (similar to exam questions): provide conclusions and interpretation to worked-out data analysis presented in the question

**Virtual Lab**
Some homework assignments will be related with a Virtual Lab activity. The link to the virtual lab will be provided on the Moodle site when needed.

The use of generative artificial intelligence (GenAI) is permitted. Where it is used the prompt shall be included, the engine used identified (e.g., Claude, Copilot, Chat-GPT), and the GenAI answer must be critiqued by the student.

While the use of GenAI is permitted during homework, the learning outcome is clearly in the mind of the student, and GenAI is not permitted during exams.

**LEARNING OUTCOMES:**
By the end of the course students will be able to:

- **Explain and apply the fundamental laws of electromagnetism**, including Coulomb's Law, Gauss's Law, Ampère's Law, and Faraday's Law
- **Solve quantitative problems** involving electric forces, electric fields, electric potential, and basic electric circuits (including RLC circuits) for both, DC and AC circuits
- **Apply the principles of electromagnetic induction** to predict and explain phenomena such as induced currents, eddy currents, and the operation of transformers and generators
- **Explain the propagation of electromagnetic waves**, including their speed, energy, and the relationship between electric and magnetic field components
- **Interpret and analyze experimental data** related to electromagnetism, including using software tools
- **Communicate scientific reasoning and solutions clearly**, both in written and oral forms, using appropriate physics terminology

**ATTENDANCE POLICY:**
As a member of our class community, you are expected to be present and on time every day. Attending class has an impact on your learning and academic success. For this reason, attendance is required for all IES Barcelona classes, including course-related excursions. If a student misses more than three classes in any course without justification, 3 percentage points will be deducted from the final grade for every additional absence. Seven unjustified absences in any course will result in a failing grade. Absences will only be justified, and assessed work, including exams, tests and presentations rescheduled, in cases of documented medical or family emergencies.

**CONTENT:**

| Week | Content | Assignments and Readings |
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| **Week 1** | Session 1: Review of prior knowledge and foundations<br><br>• Gravity<br>• Forces<br>• Basic vector algebra<br>• Basic calculus<br>• How to read a textbook | The readings related to each session are from the following book unless otherwise stated:<br>• Urone, Paul Peter (California State University, Sacramento) and Roger Hinrichs (State University of New York, College At Oswego) (Senior Contributing Authors), 2022, *College Physics 2e*<br>• Avaible on: https://openstax.org/details/books/college-physics-2e |
| | Session 2: Charges and fields<br><br>• Electric charges<br>• Electric field<br>• Superposition principle<br>• Learning to learn in the era of GenAI | • Sections 18, 18.1, 18.2 and 16.10<br>• Assigned: Homework assignment #1 |
| **Week 2** | Session 3: Coulomb's Law, Electric field lines,<br><br>• Coulomb's Law<br>• Electric field lines | • Sections 18.3, 18.4, 18.5 |
| | Session 4: Capacitor, solving for the electric field<br><br>• Capacitor<br>• Motion of charges & dipoles in an electric field | • Sections 18.6 and 19.5<br>• Due: Homework assignment #1<br>• Assigned: Homework assignment #2 |
| **Week 3** | Session 5: Gauss's Law<br><br>• Symmetry<br>• Electric flux<br>• Closed Gaussian surface<br><br>Session 6: Gauss's Law continued<br><br>• Closed Gaussian surfaces<br>• Energy review, preparation for electric potential | • Reading Gauss's Law<br><br>• Due: Homework assignment #2<br>• Assigned: Homework assignment #3 |
| **Week 4** | Session 7: Electric potential<br><br>• Potential and field<br>• Beginning circuits | • Sections 19, 19.1, 19.2 |

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| | Session 8: Dielectrics, currents and resistances<br><br>• Dielectrics<br>• Current and resistance | • Sections 19.5, 20.1, 20.2<br>• Due: Homework assignment #3<br>• Assigned: Homework assignment #4 |
| **Week 5** | Session 9: Analyzing data<br><br>• Line of best fit<br>• Tool choices (R, python, … - the choice is yours; why Excel may (only) sometimes work)<br><br>Session 10:<br><br>• Potential and field | • Section 1.4<br><br>• Due: Homework assignment #4<br>• Assigned: Homework assignment #5 |
| **Week 6** | Session 11: Fundamentals of circuits<br><br>• Circuit elements<br>• Resistors and capacitors in a circuit<br><br>Session 12: Magnetism<br><br>• Potential and field | • Sections 21.1, 21.6<br><br>• Sections 22.1, 22.2<br>• Due: Homework assignment #5<br>• Assigned: no homework assigned<br><br>• **Prepare your formula sheet for the exam!** |
| **Week 7** | **Session 13: Midterm exam**<br><br>Session 14: Magnetism, Ampére's Law<br><br>• Ampére's Law<br>• Force on a moving charge in a magnetic field | <br><br>• Sections 22, 22.4, 22.5, 22.9<br>• Due: None<br>• Assigned: Homework assignment #6 |
| **Week 8** | Session 15: Magnetic forces<br><br>• Torque on wires<br>• Induction<br>• Eddy currents<br><br>Session 16: Electromagnetic induction, LR circuits<br><br>• Faraday's Law<br>• Inductors | • Section 22.8, 23.1, 23.4<br><br>• Sections 23.2, 23.9<br>• Due: Homework assignment #6<br>• Assigned: Homework assignment #7 |
| **Week 9** | Session 17: LC circuits, Alternating current<br><br>• Phasors, reactances<br>• Resonance<br>• RLC circuit | • Section 23.12 |

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| | Session 18: RLC circuits continued | • Due: Homework assignment #7<br>• Assigned: Homework assignment #8 |
| **Week 10** | Session 19: Coulombs Law, Electric field lines, Capacitor<br>• Power<br>Session 20: Displacement current | • Section 18.1<br>• Section 24, 24.1<br>• Due: Homework assignment #8<br>• Assigned: Homework assignment #9 |
| **Week 11** | Session 21: Introduction to waves<br>• Waves in general<br>• Speed equation<br>Session 22: Electromagnetic waves | • Sections 16, 16.9<br>• Sections 24, 24.1, 24.2<br>• Due: Homework assignment #9<br>• Assigned: Homework assignment #10 |
| **Week 12** | Session 23: Electromagnetic waves continued<br>Session 24: Review of complete course material | • Sections 24.2, 24.3, 24.4.<br>• Due: Homework assignment #10<br>• Assigned: None |

**Final Exam**

**COURSE-RELATED TRIPS:**

- None.

**REQUIRED READINGS:**

- Urone, Paul Peter (California State University, Sacramento) and Roger Hinrichs (State University of New York, College At Oswego) (Senior Contributing Authors), 2022, *College Physics 2e,* available: https://openstax.org/details/books/college-physics-2e

**INSTRUCTOR BIOGRAPHY:** Born in Sant Pere de Vilamajor (Barcelona), Pep Mateu studied a math major at the Universitat Autònoma de Barcelona with a minor in Science Philosophy. Later, he continued his studies in University of Nebraska at Omaha, working as a GTA for the math department before coming back to Catalonia. Since then he has been involved with several educational programs until September 2024, when he started teaching for IES Abroad.