

PHYSICS FOR COMPUTER SCIENCE

**Grado en Computación e Inteligencia Artificial / Bachelor in
Computer Science and Artificial Intelligence BCSAI SEP-2025
PCS-CSAI.1.M.A**

Area Mathematics

Number of sessions: 30

Academic year: 25-26

Degree course: FIRST

Number of credits: 6.0

Semester: 2º

Category: BASIC

Language: English

Professor: **ALFREDO BELLO REQUENA**

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Alfredo Bello is an Experimental and Computational Physicist, specializing in Solid State and Polymer Physics. He graduated with honors at Universidad Simón Bolívar (USB) in Caracas, Venezuela obtaining the "Licenciatura en Física" degree. Then he went on to obtain an MSc and a PhD in Physics from Case Western Reserve University in Cleveland, Ohio, USA.

He returned to Venezuela and joined the research group of Physics of Crystalline and Amorphous Materials at USB, where he worked with several experimental techniques (X-Ray Crystallography, Electron Paramagnetic Resonance, Thermally Stimulated Depolarization Currents, Dielectric Constant Spectrography, etc.) in Ionic Crystals and Polymer materials. Besides the experimental setups, he also did most of the data analysis using modern computational techniques, such as Fitting experimental data to complex mathematical models using Monte Carlo Simulated Annealing approach. All this work resulted in more than 60 research papers published in peer reviewed, indexed and high impact factor international journals and more than 160 presentations and assistances to international conferences.

And of course he also taught at the undergraduate and graduate levels from Basic Physics courses for 1st. and 2nd. year engineering and science students to advanced courses in Solid State Physics, Computational Physics, X-ray and Crystallography and Polymer Physics.

Office Hours

Office hours will be on request. Please contact at:

abello@faculty.ie.edu

SUBJECT DESCRIPTION

This course introduces the basic concepts for understanding the physics behind computer science. The course begins with elementary physics regarding mechanical systems and electromagnetic forces. Secondly, we shall introduce the analysis of electric circuits. The main part describes basic models of semiconductors and how we can use them to build transistors, the key element to represent formal logic in a computer. The final part is devoted to an emergent computer science, quantum computing, where we shall introduce the basic principles of quantum mechanics.

LEARNING OBJECTIVES

Understand the basic laws of any modern electronic and computing technology. Namely:

- To understand Newton's laws and phenomena associated with electromagnetic forces.
- To understand the main phenomena associated with electromagnetic forces.
- To solve elementary DC circuits.
- To understand basic models of semiconductors.
- To understand the basic structure of transistors, and how they can be used to build logic circuits.
- To understand the basic principles of quantum mechanics.

TEACHING METHODOLOGY

IE University teaching method is defined by its collaborative, active, and applied nature. Students actively participate in the whole process to build their knowledge and sharpen their skills. Professor's main role is to lead and guide students to achieve the learning objectives of the course. This is done by engaging in a diverse range of teaching techniques and different types of learning activities such as the following:

Learning Activity	Weighting	Estimated time a student should dedicate to prepare for and participate in
Lectures	20.0 %	30.0 hours
Discussions	20.0 %	30.0 hours
Exercises in class, Asynchronous sessions, Field Work	16.7 %	25.0 hours
Group work	10.0 %	15.0 hours
Individual studying	33.3 %	50.0 hours
TOTAL	100.0 %	150.0 hours

AI POLICY

Generative artificial intelligence (GenAI) tools may be used in this course for some specific tasks/assignments with appropriate acknowledgment. If a student is found to have used AI-generated content inappropriately, it will be considered academic misconduct, and the student might fail the respective assignment or the course. If you are in doubt as to whether you are using GenAI tools appropriately in this course, we encourage you to discuss your situation with the professor.

Below, is a suggested format to acknowledge the use of generative AI tools. Please note that acknowledging AI will not impact your grade.

I acknowledge the use of [AI systems link] to [specify how you used generative AI]. The prompts used include [list of prompts]. The output of these prompts was used to [explain how you used the outputs in your work]

If AI was permitted to be used in your assignment, but you have chosen not to include any AI-generated content, the following disclosure is recommended:

No content generated by AI technologies has been used in this assignment.

PROGRAM

SESSION 1 (LIVE IN-PERSON)

Overview of the course

Introduction to physical units

SESSION 2 (LIVE IN-PERSON)

Lecture: Basic concepts in Physics and Science

- What is Physics?
- Matter, space and time
- Forces
- Equations of movement
- Doing science
- Measurements and units
- Modeling reality
- Physics and computer science

SESSION 3 (LIVE IN-PERSON)

Lecture: Newton's laws

- Forces
- Newton's First law
- Newton's Second law
- Newton's Third law
- Free body diagrams
- Equilibrium

SESSION 4 (LIVE IN-PERSON)

Lecture: Mechanical energy

- Work
- Power
- Work-energy theorem
- Kinetic energy
- Potential energy
- Conservation of mechanical energy

- Conservation of energy

SESSION 5 (LIVE IN-PERSON)

Workshop on mechanical systems.

SESSION 6 (LIVE IN-PERSON)

Lecture: Electric force and voltage

- Electric charge
- Electric force
- Electrostatic field
- Electric potential
- Electric work
- Electric Potential energy

SESSION 7 (LIVE IN-PERSON)

Lecture: Capacitance

Polarization

- Electric dipole
- Dielectrics
- Capacitors

SESSION 8 (LIVE IN-PERSON)

Workshop on electric forces and capacitance

SESSION 9 (LIVE IN-PERSON)

Lecture: Current and magnetic forces

- Electric current
- Ohm's law
- Electromotive force
- Magnetic force
- Magnetic field
- Magnetic flux
- Magnetic dipole
- Magnetic materials

SESSION 10 (LIVE IN-PERSON)

Lecture: Induction

- Faraday's law
- Lenz's law
- Alternators
- Self-inductance

- Inductors

SESSION 11 (LIVE IN-PERSON)

Workshop on magnetism and induction

SESSION 12 (LIVE IN-PERSON)

Lecture: Direct current circuits

- Circuits
- Passive components
- Active components
- Electrical measuring devices
- Kirchhoff's rules
- Transient and steady state
- Electric power
- Systematic circuit analysis

SESSION 13 (LIVE IN-PERSON)

Workshop on DC circuits: circuit analysis

SESSION 14 (LIVE IN-PERSON)

Workshop on DC circuits: a simple circuit for a simple machine learning model

SESSION 15 (LIVE IN-PERSON)

Q&A review session

SESSION 16 (LIVE IN-PERSON)

Midterm test

SESSION 17 (LIVE IN-PERSON)

Lecture: semiconductors

- Condensed matter
- Crystalline solid
- Bonding in solids
- Energy bands
- Semiconductors
- Holes
- Impurities and doping
- Electric field on semiconductors
- Inhomogeneous semiconductors

SESSION 18 (LIVE IN-PERSON)

Lecture: diodes

- P-N junction: structure
- P-N junction in equilibrium
- Polarized P-N junction
- Characteristic curve I-V
- LEDs
- Circuits with diodes

SESSION 19 (LIVE IN-PERSON)

Workshop on diodes

SESSION 20 (LIVE IN-PERSON)

Lecture: Bipolar transistors

- Transistors
- BJT transistor
- Basic functioning
- Polarization of the transistor
- Modeling the transistor
- Circuit analysis with transistors

SESSION 21 (LIVE IN-PERSON)

Workshop on circuits with BJT

SESSION 22 (LIVE IN-PERSON)

Lecture: Logic gates

- Digital circuits
- Logic gates
- Truth tables
- Logic families

SESSION 23 (LIVE IN-PERSON)

Workshop on logic gates

SESSION 24 (LIVE IN-PERSON)

Lecture: Quantum Physics I: Origins and Concepts

- Historical crisis of classical physics
- Ultraviolet catastrophe and blackbody radiation
- Photoelectric effect and Planck's hypothesis
- Bohr model of the atom

- Wave-particle duality

SESSION 25 (LIVE IN-PERSON)

Lecture: Quantum Physics II: Quantum Computing

- Superposition and entanglement
- Quantum states and measurement
- Qubits vs. classical bits
- Basic quantum logic gates
- Quantum computing
- Real-world applications: cryptography

SESSION 26 (LIVE IN-PERSON)

Workshop on Quantum Physics

SESSION 27 (LIVE IN-PERSON)

Q&A review session

SESSION 28 (LIVE IN-PERSON)

Final test on electronics and quantum physics

SESSIONS 29 - 30 (LIVE IN-PERSON)

Final exam

EVALUATION CRITERIA

criteria	percentage	Learning Objectives	Comments
Final Exam	40 %		A minimum grade of 3.5 is required to pass the course.
Group Work	20 %		A project about a topic in physics not covered in the theoretical lectures.
Class Participation	10 %		Active engagement in class: asking/answering questions/homework.
Intermediate tests	30 %		Midterm and final tests.

RE-SIT / RE-TAKE POLICY

Each student has four chances to pass any given course distributed over two consecutive academic years: ordinary call exams and extraordinary call exams (re-sits) in June/July. Students who do not comply with the 80% attendance rule during the semester will fail both calls for this Academic Year (ordinary and extraordinary) and have to re-take the course (i.e., re-enroll) in the next Academic Year.

Evaluation criteria:

- Students failing the course in the ordinary call (during the semester) will have to re-sit the exam in June / July (except those not complying with the attendance rule, who will not have that opportunity and must directly re-enroll in the course on the next Academic Year).
- The extraordinary call exams in June / July (re-sits) require your physical presence at the campus you are enrolled in (Segovia or Madrid). There is no possibility to change the date, location or format of any exam, under any circumstances.
- Dates and location of the June / July re-sit exams will be posted in advance. Please take this into consideration when planning your summer. The June / July re-sit exam will consist of a comprehensive exam. Your final grade for the course will depend on the performance in this exam only; continuous evaluation over the semester will not be taken into consideration. Students will have to achieve the minimum passing grade of 5 and can obtain a maximum grade of 8.0 (out of 10.0) – i.e., “notable” in the re-sit exam.
- Retakers: Students who failed the subject on a previous Academic Year and are now re-enrolled as re-takers in a course will be needed to check the syllabus of the assigned professor, as well as contact the professor individually, regarding the specific evaluation criteria for them as retakers in the course during that semester (ordinary call of that Academic Year). The maximum grade that may be obtained in the retake exam (3rd call) is 10.0.
- After ordinary and extraordinary call exams are graded by the professor, you will have a possibility to attend a review session for that exam and course grade. Please be available to attend the session in order to clarify any concerns you might have regarding your exam. Your professor will inform you about the time and place of the review session. Any grade appeals require that the student attended the review session prior to appealing.

Students failing more than 18 ECTS credits in the academic year after the June-July re-sits will be asked to leave the Program. Please, make sure to prepare yourself well for the exams in order to pass your failed subjects. In case you decide to skip the opportunity to re-sit for an exam during the June / July extraordinary call, you will need to enroll in that course again for the next Academic Year as a re-taker and pay the corresponding extra cost. As you know, students have a total of four allowed calls to pass a given subject or course, in order to remain in the program.

BIBLIOGRAPHY

Compulsory

- Raymond A. Serway and John W. Jewett.. (2015). *Physics for Scientists and Engineers*. Cengage Learning. ISBN 9781305401969 (Printed)
- Young, H.D., Freedman, R.A. and Ford, A.L.. (2020). *Sears and Zemansky's University physics with modern physics*. Pearson. ISBN 9780135216118 (Printed)

Recommended

- William Moebs, Samuel J. Ling, Jeff Sanny. *University Physics: Vol. I*. OpenStax. ISBN 9781947172203 (Digital)
<https://openstax.org/details/books/university-physics-volume-1>
- William Moebs, Samuel J. Ling, Jeff Sanny. *University Physics: Vol. II*. OpenStax. ISBN 9781947172210 (Digital)
<https://openstax.org/details/books/university-physics-volume-2>
- William Moebs, Samuel J. Ling, Jeff Sanny. *University Physics: Vol. III*.

OpenStax. ISBN 9781947172227 (Digital)

<https://openstax.org/details/books/university-physics-volume-3>

BEHAVIOR RULES

Please, check the University's Code of Conduct [here](#). The Program Director may provide further indications.

ATTENDANCE POLICY

Please, check the University's Attendance Policy [here](#). The Program Director may provide further indications.

ETHICAL POLICY

Please, check the University's Ethics Code [here](#). The Program Director may provide further indications.

