UAB Universitat Autònoma de Barcelona

Electronic Mechanisms

2023/2024

Code: 103289
ECTS Credits: 5

Degree	Type	Year	Semester
2501922 Nanoscience and Nanotechnology	OB	3	2

Contact

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Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

Prerequisites

Basic knowledge is required of:

.- Theory of circuits (resolution of linear circuits with resistors, capacitors and inductances). It is highly recommended to have approved the subject "Electronic instrumentation".

.- Basic electrostatic (concepts of field, electrical potential, etc.). It is recommended to have approved the subject "Electricity, magnetism and Optics."

.- Mathematics (complex numbers, basic differential equations, etc.). It is recommended that you have passed the first- and second-year mathematical courses.

Objectives and Contextualisation

- Understanding and mastery of the physical principles of semiconductors, as well as the most common electronic and photonic devices and the technology of their manufacture.

- Relate the benefits of the devices, their operation in circuits and the technological manufacturing processes, through physical analytical models, numerical simulations at a physical level, compact models and circuit simulations.

Competences

- Apply the concepts, principles, theories and fundamental facts of nanoscience and nanotechnology to solve problems of a quantitative or qualitative nature in the field of nanoscience and nanotechnology.
- Apply the general standards for safety and operations in a laboratory and the specific regulations for the use of chemical and biological instruments, products and materials in consideration of their properties and the risks.
- Communicate orally and in writing in one's own language.
- Demonstrate knowledge of the concepts, principles, theories and fundamental facts related with nanoscience and nanotechnology.
- Handle the standard instruments and materials of physical, chemical and biological testing laboratories for the study and analysis of phenomena on a nanoscale.
- Interpret the data obtained by means of experimental measures, including the use of computer tools, identify and understand their meanings in relation to appropriate chemical, physical or biological theories.
- Learn autonomously.
- Manage the organisation and planning of tasks.
- Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
- Propose creative ideas and solutions.
- Reason in a critical manner
- Recognise and analyse physical, chemical and biological problems in the field of nanoscience and nanotechnology and propose answers or suitable studies for their resolution, including when necessary the use of bibliographic sources.
- Recognise the terms used in the fields of physics, chemistry, biology, nanoscience and nanotechnology in the English language and use English effectively in writing and orally in all areas of work.
- Resolve problems and make decisions.
- Work on the synthesis, characterisation and study of the properties of materials on a nanoscale from previously established procedures.

Learning Outcomes

1. Analyse situations and problems in the field of physics and propose answers or studies of an experimental nature using bibliographic sources.
2. Apply the acquired theoretical contents to the explanation of experimental phenomena.
3. Communicate orally and in writing in one's own language.
4. Correctly use computer tools to calculate, graphically represent and interpret the data obtained, as well as its quality.
5. Correctly use specific physical and electronic simulation programs (such as SPICE) to study electronic devices.
6. Critically evaluate experimental results and deduce their meaning.
7. Describe the basics of electronic transport in semiconductors.
8. Describe the current and voltage characteristics of electronic and photonic devices in their different areas of operation.
9. Describe the electrical conduction of metals and thermal-electrical crossed effects.
10. Describe the main applications of the studied devices and situate them in the current technological context.
11. Describe the operation of electronic devices: diodes, MOS transistors, bipolar transistors and devices that emit and receive light.
12. Design basic electronic devices, establishing their relation with manufacturing technology (including materials, dimensions and doping) with their specifications on an electrical level
13. Draft reports on the subject in English.
14. Electrically characterise basic electronic devices to extract their current voltage curves in the electronic instrumentation laboratory
15. Employ information and communication technology in the documentation of cases and problems.
16. Identify and situate safety equipment in the laboratory.
17. Identify the main parameters of electronic devices that determine their benefits as well as their limitations.
18. Interpret basic texts and bibliographies in English on physics and materials.
19. Learn autonomously.

20. Make adequate use of laboratory materials and instruments.
21. Manage the organisation and planning of tasks.
22. Obtain, manage, analyse, synthesise and present information, including the use of digital and computerised media.
23. Perform bibliographic searches for scientific documents.
24. Present brief reports on the subject in English.
25. Propose creative ideas and solutions.
26. Reason in a critical manner
27. Relate experimental data with the physical and chemical properties and/or analysis of the systems that are the object of study.
28. Resolve problems and make decisions.
29. Resolve problems with the help of the provided complementary bibliography.
30. Safely handle laboratory materials and instruments.
31. Use circuit models to describe the electrical behaviour of electronic devices
32. Use data processors to produce reports.

Content

Topic 1. Semiconductor physics and electronic transport

1.1 Charge and fields
1.2 Band diagrams and density of states
1.3 Electronic transport in semiconductors

Topic 2. PN junction diode

2.1 Electrostatic of the PN junction in equilibrium
2.2 PN Union out of equilibrium. Currents
2.3 Simple circuit applications: trimmers, rectifiers, etc.

Topic 3. Bipolar transistor

3.1 Types of transistors. Bands diagrams
3.2 Current-voltage curves.
3.3 Simple circuit applications: polarization, logic gates, amplifiers, etc.

Topic 4. MOSFET transistor

4.1 The MOSFET structure
4.2 Types of current-voltage transistors and curves
4.3 Simple circuit applications: logic gates, amplifiers, CMOS circuits

Topic 5. Photonic devices

5.1 Properties of light. Light-matter interaction
5.2 Light emitters: LEDs and LASERs
5.3 Light detectors: PIN and solar cells

Topic 6. From microelectronics to nanoelectronics

6.1 More Moore. Scaling from MOSFET. Short channel effects,...
6.2 Beyond CMOS: tunnel devices, quantum dots, single-electron devices, graphene, spintronics, molecular electronics

Methodology

Guided activities:

Lectures: The teacher will explain the topics through (i) the support of notes on screen that will be available to the student in advance ("virtual campus") and (ii) small exercises or complementary explanations on the class board.

Problem seminars: The teacher will perform, or in some cases, the students themselves, example problems.

Laboratory sessions: Before completing each practical session, the student will have to prepare it and deliver at the beginning of the session the corresponding report (in English). At the end of the internship session, the student will deliver another report (in English) during the session.

Supervised activities:

Tutorials: Outside normal class, the student will be able to require the explanations of the professors of theory, problems or practices for any doubt. The use of this didactic resource is recommended to the student.

Autonomous activities:

Study: An independent study of each subject of the subject by the student is necessary.

Resolution of class problems: It is highly recommended that the student try to do the exercises in advance.

Preparation of the sessions of Laboratory: As mentioned, the student must prepare a report prior to the performance of the practices.

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.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Laboratory sessions	15	0.6	19, 3, 12, 14, 24, 21, 16, 18, 30, 25, 26, 13, 27, 5, 20, 31, 32
Lectures	20	0.8	11, 7, 9, 8, 10, 12, 17, 18, 31
Problem seminar	10	0.4	6, 3, 11, 7, 9, 8, 10, 17, 25, 26, 28
Type: Supervised			
Tutorials	5	0.2	2, 6, 3, 11, 7, 9, 8, 10, 24, 17, 25, 26, 29
Type: Autonomous			
Preparation of the sessions of Laboratory	15	0.6	1, 19, 15, 23, 21, 18, 25, 26, 13, 31, 32
Resolution of problems	15	0.6	2, 19, 11, 7, 9, 8, 10, 24, 21, 17, 22, 25, 26, 13, 27, 29, 28, 4, 20, 31
Study	27	1.08	19, 23, 21, 18, 22, 26, 29, 28, 31

Assessment

CONTINUOUS EVALUATION: The subject will be evaluated compulsorily through two partials, the practices and guided problems according to the following percentages:

.- 1st Partial Exam written: 35% of the GRADE

.- 2nd Partial Exam written: 35% of the GRADE

.- Practices of each subject: 30% of the NOTE

All three must be approved, with a minimum of 5. In case of having a grade lower than 5 in any of the two partials, you can recover the partial (s) suspended in a final exam.

.- Total final written exam: 70% of the GRADE

UNIQUE EVALUATION: Students who have opted for single assessment will have to take a final test consisting of an examination of all the theoretical syllabus and problems of the subject. This test will be carried out on the day on which the students of the continuous evaluation do the exam of the second partial. The student's grade for this exam will be 70% of the grade of the subject.

If the final grade of the exam does not reach 5, the student has another opportunity to pass the subject through the recovery exam that will be held on the date set by the coordination of the degree.

The practical part is not recoverable. Practical sessions are compulsory and students entered for single assessment must also attend and submit their assignments like other continuous assessment students.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes

1st partial exam	35%	4	0.16	2, 19, 11, 7, 9, 8, 24, 17, 26, 13, 29, 28, 4
2nd partial exam	35	4	0.16	19, 11, 7, 8, 10, 24, 17, 18, 26, 13, 28
Laboratory sessions for each topic	30%	10	0.4	1, 6, 3, 12, 14, 15, 23, 21, 16, 30, 22, 25, 27, 5, 4, 20, 31, 32

Bibliography

Basic Bibliography:

Luis Prats Viñas y Josep Calderer Cardona, Dispositius electrònics i fotònics. Fonaments. Edicions UPC, 2001

P. Horowitz and W. Hill *The Art of Electronics,Cambridge* Editorial Univ. Press (1989)

B.E.A. Salech and M.C. Theich *Fundamentals of Photonics* Editorial John Wiley & Sons

Additional bibliography for electronic devices:

MODULAR SERIES ON SOLID STATE DEVICES (Ed. Addison-Wesley):

R.F.Pierret, *Semiconductor* fundamentals (1988) / Fundamentos de semiconductores (1994)

Gerold W. Neudeck,. *The* PN Junction Diode (1989) / El diodo PN de unión (1993)

G.W.Neudeck, *The* Bipolar Junction Transistor(1989) */ El transistor bipolar de unión* (1994)

R.F. Pierret, Field effect devices (1990) / Dispositivos de efecto de campo (1994)

Additional bibliography for photonic devices:

J.Wilson *Optoelectronics: an introduction.*Editorial Prentice Hall

D.Wood. *Optoelctronic* Semiconductor Devices. Editorial Prentice Hall.

S.D. Smith. *Optoelectronic Devices*. Editorial Prentice Hall.

Additional Bibliography for nanoelectronic devices:

Rainer Waser Ed. *Nanoelectronics and Information Technology*. Editorial WILEY-VCH.

WEB**resources:**

http://nanohub.org/

Software

The software PSPICE for circuit simulation will be used