UAB
Universitat Autònoma de Barcelona

Micro and Nanosystems

Code: 103298
ECTS Credits: 6

2025/2026

Degree	Type	Year
Nanoscience and Nanotechnology	OB	4

Contact

Name: Núria Barniol Beumala

Email: nuria.barniol@uab.cat

Teachers

Núria Barniol Beumala

Francisco Torres Canals

Teaching groups languages

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

Prerequisites

It is recommended to attend the subject simultaneously or later to Nanofabrication.

Objectives and Contextualisation

The general objective of the course is that the student knows the main principles of transduction, the different structures and also the architectures involved in sensing and actuation with a micro/nanometric scale device. Special emphasis will be made for the effects of the reduction of the dimensions to the nanometer scale

Competences

- Adapt to new situations.
- 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 clearly in English.
- 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.
- Operate with a certain degree of autonomy.
- 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 correctly with the formulas, chemical equations and magnitudes used in chemistry.
- Work on the synthesis, characterisation and study of the properties of materials on a nanoscale from previously established procedures.

Learning Outcomes

1. Adapt to new situations.
2. Apply the acquired theoretical contents to the explanation of experimental phenomena.
3. Characterise micro and nanosystems to extract their main transducing characteristics.
4. Communicate clearly in English.
5. Communicate orally and in writing in one's own language.
6. Correctly observe protocols for using instrumentation, reagents and chemical waste in laboratories related to the subject.
7. Correctly use specific physical and electronic simulation programs to study electronic devices.
8. Critically evaluate experimental results and deduce their meaning.
9. Describe the elements, architectures and principles of MEMS and NEMS systems and identify their main applications.
10. Describe the existing relationship between transducer elements and specific technologies for their manufacture.
11. Describe the principles of modelling and its main tools for the simulation of transducer elements
12. Describe the principles of transduction to produce sensors and actuators and the effects of a decrease in dimensionality.
13. Design micro and nanosystems in accordance with specifications and in consideration of the technology.
14. Draft and present reports on the subject in English.
15. Identify the main transducer elements and their physical and chemical principles in mechanical structures, basic electronic devices and specific materials for transduction.
16. Interpret and rationalise the results obtained both in the laboratory and in simulation of the characterisations of micro and nanosystems and relate them with transducer processes.
17. Interpret and rationalise the results obtained in the laboratory in processes related with physics and chemistry in nanoscience and nanotechnology.
18. Interpret discrepancies between theoretical and practical results (including simulation) found in the characterisations of electronic devices.
19. Interpret texts in English on aspects related with the physics and chemistry of nanoscience and nanotechnology.
20. Learn autonomously.
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. Operate with a certain degree of autonomy.
24. Perform bibliographic searches for scientific documents.
25. Perform characterisation studies of materials and nanomaterials to extract their transducing properties in micro and nanosystems.
26. Predict behavioural changes in transducers and devices in accordance with a decrease in their size to the nanometric scale.
27. Propose creative ideas and solutions.
28. Rationalise the results obtained in the laboratory in terms of physical magnitudes and their relation with the observed physical phenomena.
29. Reason in a critical manner
30. Recognise and propose figures of merit for micro and nanosystems.
31. Recognise the terms used in the physics and chemistry of surfaces, supramolecular chemistry and molecular recognition.
32. Resolve problems and make decisions.
33. Resolve problems with the help of the provided complementary bibliography.
34. Work correctly with the formulas, chemical equations and magnitudes used in chemistry.

Content

Unit 1. Introduction
Definition of basic concepts (sensor / actuator / transducer). Micro and nanosystems versus micro and nanoelectromechanical systems (MEMS-NEMS). Historical origin Micro and nanosystem technology. Relationship with microelectronics technology and micro and nanofabrication techniques. Industrial applications and market prospects.

Unit 2. Transducer elements.
Basic MEMS mechanical structures: levers, bridges, membranes. Materials and principles of transduction: piezo-resistive, piezoelectric, electrostatic, optical, electromagnetic.

Unit 3. Architectures and principles of operation
Micro and nanosystems DC (static) and AC (dynamic or resonant). Techniques of actuation and detection. Digital and analogue architectures for the transduction, conditioning, amplification and transmission of the signal.

Unit 4. Modeling and simulation
Modeling and simulation of transducer elements: finite element simulation tools (FEM). Mechanical, electronic, electromagnetic and other transduction domains. Modeling and simulation at the system level.

Unit 5. Dimensional scaling
Study of the effects of dimensional scaling on the characteristics and merit figures of micro and nanosystems. Advantages of microsystems with respect to systems of millimetric dimensions. Limits of scaling in the nano regime.

Unit 6. Applications of micro and nanosystems
Sensors: temperature, pressure, displacement, acceleration, force, flow, gases, mass. Applications to chemical and biological sensing. Optical applications Actuators: micromotors, microvals, microswitches. Signal processors: RF-MEMS, micro oscillators, filters, mixers. Power generation: scavengers, fuel micropiles.

Practices
-Design and simulation of an M / NEMS

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Concepts and theoretical teaching	27	1.08	1, 2, 5, 9, 12, 10, 13, 15, 19, 23, 26, 27, 29, 31, 30, 14
Laboratory	10	0.4	1, 2, 8, 4, 5, 3, 18, 17, 16, 22, 23, 27, 28, 29, 25, 14, 32, 34, 7, 6
Practical lessons with exercises	15	0.6	2, 20, 13, 24, 21, 19, 22, 23, 26, 27, 29, 25, 30, 33, 32
Type: Autonomous			
Exercises solving	20	0.8	20, 13, 24, 21, 19, 23, 26, 27, 29, 30, 33, 32
Reading, resolution and writing of the laboratory reports	20	0.8	2, 8, 5, 13, 18, 17, 16, 23, 26, 28, 14, 34, 7
Study for the assimilation of concepts	46	1.84	2, 20, 24, 16, 19, 22, 30, 33

Theoretical classes Explanation by the teacher of the fundamental concepts of each of the topics. Part of the concepts will be introduced as a resolution of specific cases.

Problem classes Resolution and discussion of from the exercises and problems delivered to students.

Laboratory. Practical work in the specific laboratory. Part of the work will have a specific section that will require a previous resolution based on mathematical calculations or by simulation tools.

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 a written report on the design of a Micro / nanosystem.	20%	4	0.16	1, 20, 4, 5, 9, 10, 13, 24, 21, 15, 16, 19, 22, 23, 26, 27, 29, 31, 30, 14, 33, 34, 7
Laboratory work evaluation	30%	2	0.08	2, 8, 4, 5, 13, 3, 24, 21, 18, 17, 16, 22, 23, 27, 28, 29, 25, 31, 30, 14, 34, 7, 6
Written partial exams (2)	25% per partial exam	6	0.24	5, 9, 12, 11, 10, 13, 15, 18, 17, 16, 19, 26, 27, 29, 31, 30, 14, 32

The evaluation of the subject will have 3 differentiated sections:

a) There will be compulsory two written examinations on the concepts taught in the theoretical and problems (with a weight of 25% for each partial exam). For averaging a minimum qualification of 3.5 is needed in each partial exam. At the end of the course there will be a final final examination so that students can approve or improve their qualification. Students must do both partial examinations for attend this final exam. In the event that the student is not presented at both partial sessions, the student will be qualified as "non-evaluable". A minimum qualification of 4,5 is required in this section to make the weighting with sections b) and c).

b) A design project of a micro-nanosystem will be proposed. The work must be performed in a team and will be presented in the form of a poster at the end of the course. The weight of this work will be 20%. Obligatory and non-recoverable activity.

c) The practices, which are mandatory, will have a final weight of 30%. The evaluation of the same will be done through written reports made by the students in which the experimental results of the practices will be detailed, valuing the interpretation and discussion of the results insofar as they are theoretically and / or simulated.. Obligatory and non-recoverable activity.
To obtain an Honors Matriculation qualification (which can be given to 5% of the number of enrolled students), you must have grades above 9 in all sections and with a final average above 9.3
Single assessment modality:
Students who have accepted the single assessment modality will have to take a final test which will consist of an examination of the entire theoretical and problems parts of the subject. In addition, students will have to hand in the reports of all the practices carried out and the design work. This test will be carried out on the day on which the students of the continuous assessment take the second partial exam. The student's qualification will be:
Subject grade = 50% of the final exam grade + 30% of the laboratory grade + 20% of the design work grade.
If the final grade 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 degree coordinator. In this test you can recover 50% of the grade corresponding to the theory and problems part. The practical part and the design work are not recoverable.

Bibliography

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Understanding MEMS : Principles and Applications, Luis Castañer, Willey, ISBN: 978-1-119-05542-6 (2015), eBook

MEMS Mechanical Sensors (Artech House microelectromechanical systems (MEMS) series), Steve Beeby et al. ISBN: 978-1-58053-536-6 (2004), eBook

Practical MEMS. Ville Kaajakari. Small Gear Publishing. ISBN: 978-0-9822991-0-4(2009).

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- Sensor Materials, P.T.Moseley and A.J. Crocker, Ed. Institute of Physiscs Publishing (IOP), London 1996

- Sensor technology and devices,L. Ristic editor, Ed. Artech House, Boston 1994

- Microsensors, Principles and Applications, J.W. Gardner, Ed. John Wiley &sons, Chichester, 1994

- Sensorsand Tranducers, M.J. Usher and D.A. Keating,Ed. Macmillan, London, Second Edition 1996

Software

Elmer, software finite elements modelization, http://www.elmerfem.org/blog/documentation/

Salome, software for the design of the systems for software Elmer, https://www.salome-platform.org/

Pspice, software for the electrical simulation, https://www.orcad.com/pspice-free-trial

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	1	Catalan	first semester	morning-mixed
(PLAB) Practical laboratories	1	Catalan	first semester	afternoon
(PLAB) Practical laboratories	2	Catalan	first semester	afternoon
(PLAB) Practical laboratories	3	Catalan	first semester	afternoon
(TE) Theory	1	Catalan	first semester	morning-mixed