UAB
Universitat Autònoma de Barcelona

Micro and Nanosystems

Code: 106821
Credits: 6

2026/2027

Degree programme	Type	Course
Nanoscience and Nanotechnology	OP	4

Contact lecturer

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Group languages

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

Prerequisites

It is recommended to have previously taken the course Nanofabrication or to take it concurrently.

Objectives

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

Learning outcomes

- CM19 (Work independently to solve problems and practical cases related to nanoscale phenomena.) Work independently to solve problems and practical cases related to nanoscale phenomena.
- KM33 (Recognise the main principles of transduction, sensing and actuation at the micro- and nano-scale.) Recognise the main principles of transduction, sensing and actuation at the micro- and nano-scale.
- SM30 (Predict the behaviour, properties and uses of nanomaterials and nano-systems as a consequence of low dimensionality.) Predict the behaviour, properties and uses of nanomaterials and nano-systems as a consequence of low dimensionality.

Contents

Basic concepts: sensor/actuator/transducer. Micro- and nanoelectromechanical systems (MEMS-NEMS).

Transduction elements. Basic mechanical structures in MEMS: cantilevers, bridges, membranes.

Materials and transduction principles: piezoresistive, piezoelectric, electrostatic, optical, electromagnetic. DC (static) and AC (dynamic or resonant) micro- and nanosystems. Actuation and detection techniques.

Modeling and simulation of transduction elements: finite element method (FEM) tools. Mechanical, electronic, electromagnetic, and multi-domain simulators. System-level modeling and simulation.

Dimensional scaling: study of scaling effects on the characteristics and figures of merit of micro- and nanosystems. Advantages of microsystems over millimeter-scale systems. Limits of scaling in the nanometric regime.

Applications of micro- and nanosystems. Case studies. inertial, environmental, temperature, pressure, displacement, acceleration, force, and mass sensors. Applications in chemical and biological sensing.

Laboratory work:

- Design and simulation of an M/NEMS
- Experimental characterization of a MEMS

Learning activities and methodology

Title	Hours	ECTS	Learning outcomes
Resolution, preparation and edition of the written reports and/or oral expositions	25	1	CM19, KM33, SM30
Laboratory	10	0.4	CM19, KM33, SM30
Problem solving	20	0.8	CM19
Study for the assimilation of concepts	38	1.52	CM19, KM33, SM30
Problem solving lessons	10	0.4	CM19, KM33, SM30
Theoretical classes	32	1.28	KM33, SM30

Theory classes: explanation by the instructor of the fundamental concepts of each topic. Some concepts will be introduced through the resolution of specific case studies.

Problem-solving sessions: resolution and discussion by the instructor of selected exercises and problems provided to students.

Practical classes: laboratory sessions carried out in a specialized lab. Some practical activities will follow a specific script and will require solutions based on mathematical calculations or using 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

Continuous assessment activities

Title	Weight	Hours	ECTS	Learning outcomes
Written exams (2)	25% per partial exam	6	0.24	CM19, KM33, SM30
Laboratory Assessment	20%	3	0.12	CM19, SM30
Oral Presentation or written report of one of the cases	30%	6	0.24	CM19, KM33, SM30

The course assessment will consist of three distinct components:

a) Two written exams will be mandatory, covering the concepts taught in theory and problem-solving sessions (each partial exam accounting for 25%). To average the two partial exams, a minimum grade of 3.5 is required in each. At the end of the course, a final exam will be offered to allow students to pass or improve their grade. To take this final exam, students must have sat both partial exams. Failure to attend both will result in a "Not assessable" grade. A minimum grade of 4.5 in this component is required to be averaged with parts b) and c).

b) A design project on a micro/nanosystem will be assigned, to be completed in groups and presented as a poster and oral presentation at the end of the course. This component accounts for 30%. Mandatory and non-recoverable.

c) Laboratory sessions are mandatory and account for 20% of the final grade. Assessment will be based on a written report detailing experimental results, with special emphasis on interpretation and discussion in comparison with theoretical and/or simulated results. Mandatory and non-recoverable.

To obtain an Honors distinction (awarded to up to 5% of enrolled students), it is required to achieve grades above 9 in all components and a final average above 9.3.

Use of AI:

For this course, the use of Artificial Intelligence (AI) technologies is permitted exclusively for support tasks, such as literature or information search, text correction, translation, and assistance in the writing and presentation of assignments. Students must clearly identify which parts have been generated using this technology, specify the tools used, and include a critical reflection on how these have influenced the process and the final outcome of the activity. Lack of transparency in the use of AI in assessed activities will be considered a breach of academic integrity and may result in partial or full penalties in the grade.

The commission of any irregularity in an assessment activity (academic fraud, plagiarism, or improper use of Artificial Intelligence (AI), unless such use is expressly authorized in the course guide) that may lead to a significant alteration of the assessment result will result in that assessment activity being graded with a 0 (zero) . If the course guide establishes that obtaining a minimum grade in that assessment activity is an essential requirement to pass the course, or if multiple irregularities occur in the assessment activities of the same course, the final grade for the course will be 0 (zero). Furthermore, disciplinary proceedings may be initiated against any student who engages in any of these irregularities.

Single assessment:

Students who opt for single assessment must complete a final exam covering all theoretical and problem-solving content of the course. They must also submit reports for all laboratory sessions and the design project.

This exam will take place on the same day as the second partial exam of continuous assessment students. The final grade will be calculated as:

Final grade = 50% final exam + 30% laboratory + 20% design project.

If the final grade is below 5, students will have a second opportunity through the resit exam scheduled by the program coordination. In this case, up to 50% corresponding to the theory and problem-solving component may be recovered. The laboratory and design project components are not recoverable.

Bibliography

Analysis and design principles of MEMS devices. Minhang, Bao. ISBN: 978-0-444-51616-9, (2005), eBook

Sensors, Actuators and their interfaces: a multidisciplinary introduction. Nathan Ida, 978-1-61353-006-1, Institution of Engineering and Technology (The IET). (2020), eBook

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).

Microsystems Design. S.D. Senturia. Kluwer Academic Publishers (2001).

Fundamentals of Microfabrication. The Science of Miniaturization (2nd edition). M.J. Madou. CRC Press, (2002).

Sensors. Vol.7. *Mechanical Sensors*. W. Göpel, J. Hesse, J.N. Zemel. Wiley-VCH.

Sensors (Update). Vol.4. H. Baltes, W. Göpel, J. Hesse. Wiley-VCH.

Vigna, B., Ferrari, P., Villa, F. F., Lasalandra, E., & Zerbini, S. (2022). *Silicon Sensors and Actuators: The Feynman Roadmap.* Springer International Publishing AG. https://doi.org/10.1007/978-3-030-80135-9 eBook

Bhushan, B. (Ed.). (2017). *Springer Handbook of Nanotechnology* (4th ed. 2017.). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-54357-3 eBook

Software

Finite Element Modelization software. Ansys, student version: https://www.ansys.com/academic/students/ansys-student

Course groups and languages

The information provided is provisional until November 30. After this date, you will be able to consult the language of each group through this link. To access the information, you will need to enter the course CODE

Type of teaching	Group	Language	Semester	Shift
(TE) Theory	1	Catalan	first semester	morning-mixed
(PAUL) Classroom practices	1	Catalan	first semester	morning-mixed
(PLAB) Practical laboratories	1	Catalan	first semester	afternoon