Course Guide [Codi UD] – [Sigles UD] – Biosensors

Unit in charge	Barcelona East School of Engineering			
Teaching unit:	*Electronic engineering*			
Academic year	2025	**Credits**		*6*
Lenguages		*Spanish and Catalan*		

Lecturer	
Coordinating lecturer:	Lexa Nescolarde (710: Department of Electronic Engineering) Georgina Company (710: Department of Electronic Engineering)
Others:	Lexa Nescolarde Georgina Company Giovanni Vescio

PRIOR SKILLS

Have passed the subject "Sensors and biomedical signal conditioning" or, failing that, the Instrumentation subject of the degrees in biomedical engineering and electronic engineering respectively.

TEACHING METHODOLOGY

· AF.1.- Presentation of theoretical content.
· AF.2.- Resolution of exercises, problems and cases.
· AF.4.- Discussion of problems or scientific articles.
· AF.5.- Participation in seminars and conferences.
· AF.6.- Carrying out individual and cooperative work.

LEARNING OBJECTIVES OF THE SUBJECT

1. Understand the fundamental principles of biosensors
   - Develop a deep understanding of the basic principles of biosensors, including sensing mechanisms.
   - Learn the scientific foundations of biosensor technology, including biomolecular recognition, transduction principles, and signal processing.
2. Explore the design and fabrication of biosensors
   - Gain hands-on experience with the design, development, and fabrication of various types of biosensors.
3. Analyze and interpret sensor signals
   - Understand how to process and interpret signals generated by biosensors, including data acquisition, signal amplification, and noise reduction.
4. Develop skills in biosensor applications
   - Explore the broad applications of biosensors in healthcare, including point-of-care diagnostics and disease biomarker detection.
   - Understand the role of biosensors in monitoring physiological parameters (e.g., glucose, pH, oxygen levels).
5. Evaluate the performance and limitations of biosensors
   - Understand how to evaluate the performance of a biosensor, focusing on parameters such as sensitivity, selectivity, response time, stability, and reproducibility.
   - Study the challenges associated with integrating biosensors into real-world environments, including issues of calibration, scalability, and long-term reliability.
6. Investigate emerging trends and technologies in biosensing
7. Develop critical thinking and problem-solving skills
   - Foster the ability to critically evaluate biosensor technologies and propose innovative solutions to existing challenges in biosensing.
8. Collaborate on interdisciplinary research projects
   - Participate in group projects that simulate real-world biosensing applications and enable teamwork and communication skills.
9. Apply biosensor knowledge to real-world case studies
   - Apply theoretical knowledge to practical scenarios and case studies in areas such as medical diagnostics, environmental monitoring, and food safety.
   - Develop the skills to design and implement biosensing systems for specific applications, ensuring that they meet the necessary regulatory, ethical, and technical standards.

STUDY LOAD

Type		Hours	Percentage
Hours large group		42,0	28.00 %
Hours small group		14,0	9.00 %
Self study		94	63.00 %
Total learning time:	150h		

CONTENTS

Content 1:	Bioelectrodes

Description:

1. Introduction
2. The electrode-electrolyte interface
3. Polarization
4. Polarizable and non-polarizable electrodes
5. Electrode behaviour and circuit models
6. Electrical properties of the electrode-skin interface
7. Electrode design
8. Electrode standards
9. Internal electrodes
10. Electrode arrays
11. Microelectrodes
12. Electrodes for electrical tissue stimulation

Related activities:

- Seminar 1, session 1: Scientific articles analysis.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 1h
Self-study: 8h

Content 2:	Biosensors

Description:

1. Introduction
2. Immobilization of the biosensor agent
3. Biosensor parameters
4. Amperometric biosensors
5. Potentiometric biosensors
6. Conductometric and impedimetric biosensors
7. Biocompatibility of implantable sensors

Related activities:

- Seminar 1, session 2: Scientific articles analysis.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 1h
Self-study: 8h

Content 3:	Basic sensor

Description:

1. Transducer Basics
2. Sensor Amplification
3. The Operational Amplifier
4. Limitations of Operational Amplifiers
5. Instrumentation for Electrochemical Sensors
6. Impedance-Based Biosensors
7. FET-Based Biosensors

Related activities:

- Exercises and problems.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 1h
Self-study: 8h

Content 4:	Instrumentation for other sensor technologies

Description:

1. Temperature Sensors and Instrumentation
2. Mechanical Sensor Interfaces
3. Optical Biosensor Technology
4. Transducer Technology for Neuroscience and Medicine

Related activities:

- Exercises and problems.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 1h
Self-study: 8h

Content 5:	Basic sensor structures

Description:

1. Impedance-type structures
2. Semiconductor devices as sensors
3. Sensors based on the propagation of acoustic waves
4. Calorimetric sensors
5. Electrochemical cells as sensors
6. Sensors with optical waveguides

Related activities:

- Seminar 2, session 1: Scientific articles analysis.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 1h
Self-study: 8h

Content 6:	Physical sensors and their applications in biomedicine

Description:

1. Temperature measurement
2. Other applications of temperature sensors
3. Mechanical sensors in biomedicine
4. Ultrasonic sensors
5. Detectors in radiology
6. Biomedical applications of magnetic field sensors
7. More applications of physical sensors

Related activities:

- Seminar 2, session 2: Scientific articles analysis.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 1h
Self-study: 8h

Content 7:	Capacitive microsensors for biomedical applications

Description:

1. Introduction
2. The Capacitive Approach
3. Applications in the Medical Field
4. Capacitive Sensor Manufacturing Technologies
5. Capacitive Sensor Performance Issues
6. Capacitive Electronic Interfaces for Implantable Applications

Related activities:

- Seminar 3, session 1: Scientific articles analysis.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 1h
Self-study: 8h

Content 8:	Glucose sensors

Description:

1. Introduction
2. The Case for Novel Glucose Sensors
3. The Ideal Glucose Sensor
4. Glucose Sensors and Detection Methodologies
5. Remaining Challenges for Sensor Development
6. Blood Glucose Prediction

Related activities:

- Seminar 3, session 2: Scientific articles analysis.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 1h
Self-study: 8h

Content 9:	Optical sensors

Description:

1. Introduction
2. General principles of optical biosensing
3. Instrumentation
4. In vivo applications
5. In vitro diagnostic applications

Related activities:

- Seminar 4, session 1: Scientific articles analysis.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 1h
Self-study: 8h

Content 10:	Oxygen sensors

Description:

1. Introduction
2. Oxygen transport in the human body
3. Oxygen in arterial blood: pulse oximetry
4. Oxygen in arterial blood: continuous intra-arterial po2 measurement
5. Oxygen in tissues: transcutaneous oxygen
6. Oxygen in venous blood: pulmonary artery oximetry

Related activities:

- Seminar 4, session 2: Scientific articles analysis.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 1h
Self-study: 8h

Content 11:	Sensors for the measurement of chemical quantities in biomedicine

Description:

1. Sensors for monitoring blood gases and pH
2. Optical oximetry
3. Other applications of chemical sensors

Related activities:

- Seminar 5, session 1: Scientific articles analysis.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 2h
Self-study: 7h

Content 12:	Chemical biosensors

Description:

1. Enzyme biosensors
2. Affinity biosensors
3. Living biosensors
4. Direct methods for monitoring bioactive compounds

Related activities:

- Seminar 5, session 2: Scientific articles analysis.

Dedication: total hours

Large group/Theory: 3.5 h
Guided activities: 2h
Self-study: 7h

GRADING SYSTEM

Seminar notes (S) = 20%
Midterm Exam (ME) = 30%
Final Exam (FE) = 50%
Nota final (Nf): 0.20*S + 0.30*ME + 0.50*FE

Examination rules

1. There will be an evaluation of Guided activities (face-to-face or non-face-to-face) corresponding to the submission of proposed works (type S). These can be individual or in groups, according to the criteria of each teacher.
2. There will be a partial exam (ME) in the first half of the subject and a final exam (FE), of a maximum of 2 hours duration, which will consist of questions related to theoretical knowledge of the subject content and aimed at assessing the learning objectives achieved by the student.
There will be no re-evaluation exam in this subject.

BIBLIOGRAPHY

Basic:

1. J. G. Webster. (1990). Encyclopedia of Medical Devices and Instrumentation, 1st ed. USA: John Wiley & Sons, Inc.
2. Pethig, R., & Smith, S. (2012). Introductory Bioelectronics: For Engineers and Physical Scientists. Wiley-Blackwell.
3. J. G. Webster, Medical Instrumentation Application and Design, 4th Edition. John Wiley & Sons, Incorporated, 2009.
4. Harsányi, G. (2000). Sensors in biomedical applications: fundamentals, technology & applications. Technomic Pub. Co.

Complementary:

RESOURCES

Other resources:

Class material available at ATENEA