Instrumentation engineering (INEN) program, "Instrumentation engineering" department

Course Unit Title	**Biosensor, MEMS and Biorobotics**
Course Unit Code	VTES-B04
Type of Course Unit	Elective
Level of Course Unit	3 rd year INEN program
National Credits	6
Number of ECTS Credits Allocated	6
Theoretical (hour/week)	2
Practice (hour/week)	-
Laboratory (hour/week)	2
Year of Study	3
Semester when the course unit is delivered	6
Course Coordinator	Yusubov Elvin
Name of Lecturer (s)	Yusubov Elvin
Name of Assistant (s)	-
Mode of Delivery	Face to Face
Language of Instruction	English
Prerequisites	-
Recommended Optional Programme Components	-

Course description:

Fundamentals of MEMS fabrication techonology, sensor component design and system integration issues are main focus this course. Advantages and disadvantages, application (biotech, medical, etc.), commercialization, manufacturability, packaging, and interfacing of the techonology are also covered. A design project is assigned via case study in this class. .

Objectives of the Course:

This course will cover the theory and principles of major sensing/actuation mechanisms (including electrostatic, piezoelectric, thermal, piezorezistive, electromagnetic) and electromechanical concepts which are relevant for the design of MEMS devices, micro sensors and actuators. The course will teach the basic design principles for MEMS and micro/nanoscale devices, will discuss the important application areas of MEMS (RF, Bio, Optics) and nanotechnology; as well as, the fundamental principles of microfabrication and micromachining techniques for micro/nano devices and systems

Learning Outcomes

At the end of the course the student will be able to		Assessment
1.	Understand the differences between MEMS bio-sensors	1,3
2.	Explain MEMS manufacturing technology	1,2,3
3.	Understand MEMS sensor and actuators based on different physical effects	2,3
4.	Explain types of different biorobots	2,3
5.	Explain applications of biorobotics	1,3

Assessment Methods: 1. Final Exam, 2. Presentation, 3. Midterm exam

Course's Contribution to Program

		CL
1	Ability to develop as a specialist in the field of fundamental sciences and apply basic knowledge.	4
2	Ability to analyze and model functional and structural schemes of various purpose devices and systems.	3
3	Ability to use modern methods and tools, creation, selection, and application of engineering and information technology tools and modern devices and equipment.	4
4	The ability to use the strategy of team cooperation in the exchange of information,	5

	knowledge, and experience to achieve the set goal.	
5	As a result of training, the ability to use engineering knowledge, mathematical models, and basic concepts of physics and chemistry in production and technological processes, automation, measurement, and control systems.	4
6	The ability to use modern software to process technical documents of devices, design their structures, and algorithmize processes.	4
7	The ability to apply artificial intelligence to improve the quality characteristics of measurement and control systems.	1
8	The ability to process information acquisition, processing, and transmission processes based on schematic and programmable logical integrated circuits.	3
9	Ability to use knowledge to improve quality indicators and environmental safety of production processes.	4
10	Self-development ability to apply theoretical and experimental knowledge in solving modern engineering problems.	4

CL: Contribution Level (1: Very Low, 2: Low, 3: Moderate, 4: High, 5: Very High)

Course Contents

Week	Chapter	Topics	Exam
1	[1], ch.1, p.1; [2], ch.1; [4], ch.1; [6], ch.1	**LECTURE**: Introduction to Biosensors, MEMS and bio-robotics **LAB**-Introduction to the simulation softwares for biosensor, MEMS and biorobotics	
2	[1], ch.1, p.2;	**LECTURE** Biosensor Classification **LAB**- Practicing fundamental embedded programing techniques to establish a connection between MEMS sensor/ micro-motors with a microcontroller	
3	[1], ch.3	**LECTURE**: Biosensor Signal Transducers **LAB-** Interfacing a Piezo MEMS microphone with a microcontroller	
4	[2], ch.2; [3], ch.1,9;	**LECTURE**: Microfabrication technology essentials, MEMS process flow, Scaling laws for MEMS **LAB-** Interfacing a force MEMS sensor with a microcontroller	
5	[2], ch.5; [3], ch.8;	**LECTURE**: Thermal MEMS sensor and actuators **LAB**- Interfacing a flex MEMS sensor with a microcontroller	
6	[2], ch.6,7; [3], ch.4;	**LECTURE**: Piezoresistive and Piezoelectric MEMS sensor and actuators: **LAB**- Interfacing an ultrasonic MEMS microphone with a microcontroller	
7	[2], ch.4; [3], ch.5;	**LECTURE**: Electrostatic MEMS sensor and actuators **LAB**- Interfacing an MPU6050 MEMS acceloremeter with an ESP32 microcontroller	Midterm
8	[2], ch.8;	**LECTURE**: Magnetic MEMS sensor and actuators **LAB**- Interfacing an MPU6050 MEMS acceloremeter with an ESP32 microcontroller	
9	[4], ch.1; [6], ch.1;	**LECTURE**: Introduction to Biologically Inspired Robotics **LAB**- Interfacing an MPU6050 MEMS gyroscope with an ESP32 microcontroller	
10	[5], ch.2	**LECTURE**: State observation and feedback control in robotic systems for therapy and surgery **LAB**-Interfacing a micro-servo motor with a microcontroller	
11	[5], ch.3;	**LECTURE**: Robin Heart surgical robot **LAB**- Interfacing a micro-bipolar step motor with a microcontroller	
12	[5], ch.4;	**LECTURE**: Soft robotic grasper **LAB**- Interfacing a micro- biaxial step motor with a microcontroller	
13	[5], ch.11,13; [6], ch.4,	**LECTURE**: Medical nanorobots **LAB**- Interfacing a micro DC motor with a microcontroller	

14	[5], ch.1; [6], ch.2-3,	**LECTURE**: Human-robot interaction for rehabilitation scenarios **LAB**- Interfacing a micro DC motor with an encoder to a microcontroller	
15	[4], ch.13	**LECTURE**: Multifunctional Biorobotic Actuators **LAB**- Interfacing a micro vibration motor with a microcontroller	
16			Final exam

Recommended Sources

TEXTBOOK(S)

1. Gennady Evtugyn, "Biosensors Essentials", Springer-Verlag Berlin Heidelberg 2014 DOI 10.1007/978-3-642-40241-8
2. Chang Liu, "Foundations of MEMS", 2nd edition, Pearson, Essex, England, 2012. (ISBN-10: 0273752243, ISBN-13: 9780273752240)
3. Luis Castañer, "UNDERSTANDING MEMS PRINCIPLES AND APPLICATIONS", John Wiley & Sons Ltd , 2016, the UK
4. Yunhui Liu and Dong Sun, "BIOLOGICALLY INSPIRED ROBOTICS", by Taylor & Francis Group, LLC, 2012
5. Ahmad Taher Azar, "Control systems design of bio-robotics and bio-mechatronics with advanced applications", Academic Press, Elsevier, 2020
6. ShivSanjeevi Sripathi, "Biorobotics in Medicine", Arcler Press, 2023, Canada

Additional information will be distributed either electronically or delivered in printed forms.

Assessment

Attendance	0%	Less than 75% class attendance results in NA grade
Presentation	10%	
Lab	10%	
Quiz	10%	
Midterm Exam	20%	Written Exam
Final Exam	50%	Written Exam
Total	100%	

Assessment Criteria

Final grades are determined according to the Academic Regulations of Azerbaijan State Oil and İndustry University for undergraduate studies

Course Policies

- Attendance of the course is mandatory.
- Material presented in the lecture as well as assigned readings will be included in testing.
- Late assignments will not be accepted unless an agreement is reached with the lecturer.
- Cheating and plagiarism will not be tolerated.
- Cheating will be penalized according to the Azerbaijan State Oil and Industrial University General Student Discipline Regulations

ECTS allocated based on Student Workload

Activities	Number	Duration (hour)	Total Workload (hour)
Course duration in class	15	4	60
Presentation	1	8	8
Self-study	15	3	45
Tutorials	15	3	45
Midterm Examination	1	3	3
Preparation for midterm exam	1	8	8
Final Examination	1	3	3
Preparation for final exam	1	18	18
Total Workload			190
Total Workload/30(h)			6.3

ECTS Credit of the Course	6