Bachelor program,
Instrumentation Engineering (INEN) program, "Instrumentation Engineering" department

Course Unit Title	**Biomedical signals processing and analysis**
Course Unit Code	VTES-B06-3
Type of Course Unit	Elective
Level of Course Unit	3rd year INEN program
National Credits	
Number of ECTS Credits Allocated	8
Theoretical (hour/week)	2
Practice (hour/week)	1
Laboratory (hour/week)	2
Year of Study	3
Semester when the course unit is delivered	5
Course Coordinator	Assoc. Prof. Ismailov Bahram
Name of Lecturer (s)	Assoc. Prof. Ismailov Bahram
Name of Assistant (s)	-
Mode of Delivery	Face to Face, Seminar.
Language of Instruction	English
Prerequisites	-
Recommended Optional Program Components	-

Course description:

An introductory course that provides basic knowledge and concepts about the sources and types of bio potentials on the surface of the patient's body. Using myographic, oculographic, cardiographic and encephalographic bio-potentials as examples, the forms, frequency and amplitude range of diagnostic information measured are considered. The course also examines sensors, noise sources and methods for cleaning noisy measurement signals. Students will study Fourier transform methods, spectral and correlation analysis of diagnostic signals, methods for analysing non-stationary and multi-component signals. They will study and practise methods of visualising measurement diagnostic information. They will be familiarised with methods of using AI to detect, classify and diagnose manifestations of diseases identified during the analysis of diagnostic signals.

Objectives of the Course:

The aim of the course is to familiarize students with the basic measuring biomedical signals, technical means of their measurement and primary processing and transformation, analysis of informative parameters of measured signals, modern methods of visualization and visual analysis are considered.

Learning Outcomes:

At the end of the course the student will be able to		Assessment
1	Have knowledge of measuring electrical biomedical potentials using invasive and non-invasive methods in biomedical objects;	1, 3
2	Know the methods of collecting and primarily processing biomedical potentials using radio-electronic devices;	1, 3
3	Be able to use analog-to-digital converters in measurement experiments to digitize analog measurement information and digital-to-analog converters to convert digital codes into therapeutic signals;	1, 3
4	Be able to process primary measurement information using amplifiers and apply various filters to clean up noisy signals;	1, 3
5	Create simple simulation models of measuring devices using the MULTISIM program and analyze the results of measurements and simulations using the MATLAB program.	1, 3

Assessment Methods: 1. Final Exam, 2. Presentation, 3. Midterms

Course's Contribution to Program

		CL
1	Ability to measure biomedical potentials using the principles of physics, chemistry, radio electronics and measurement engineering.	3
2	Ability to perform laboratory measurement experiments using various electrical measuring instruments and extract informative data.	1
3	Ability to use the fundamentals of mathematics, algorithmic principles and methods of computer engineering in modeling and simulating designed electronic devices, analyze and interpret data using statistical methods.	4

4	Ability to use modern measuring instruments and devices to control electrical and electromechanical parameters of devices used in medical practice.	1
5	Ability to select algorithms and use appropriate electronic devices and devices for performing design tasks and solving these problems in measurement engineering, as well as the ability to eliminate malfunctions that may occur in diagnostic, therapeutic and surgical equipment.	1
6	Ability to design measuring devices and systems, and select their electronic components, taking into account such constraints as economics, ecology, safety and social aspects.	4
7	Ability to use language skills to share and acquire some knowledge from foreign sources.	1
8	Ability to analyze a problem, identify key requirements, justify an idea, and critically evaluate and compare results.	4
9	Ability to understand the professional, ethical, legal, and safety issues and responsibilities specific to engineering.	3
10	Ability to work productively in multidisciplinary teams, especially on projects requiring engineering skills, and to carry out all work in accordance with relevant laws, regulations, standards, practices, and guidelines.	3

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.1-11 [2] Ch. 2 p. 3-6	**LECTURE:** Introduction to Biomedical Signals. • The Nature of Biomedical Signals. Examples of Biomedical Signals. **LAB -** What Is a "Signal"? Analog, Discrete, and Digital Signals.	
2	[1], Ch,1, p.12-56 [1] Ch.1. p.1-4 [1] Ch.1, p.4-42	**LECTURE:** Examples of Biomedical Signals. ENG, EMG, ECG, EEG. **LAB -** The Nature of Biomedical Signals **SEMINAR:** The nature of biomedical signals. Examples of biomedical signals	
3	[1] Ch.2, p. 71-80 [1] Ch.1 p.11-21	**LECTURE:** Interaction and mutual influence • Concurrent, Coupled, and Correlated Processes. EMG and VMG; ECG and PCG; and others. **LAB -** The electroneurogram (ENG), The electromyogram (EMG), The electrocardiogram (ECG)	
4	[1], Ch.4, p. 233-249, 255 [1] Ch.9 p.171-176 [1] Ch.1, p.12-56	**LECTURE:** Detection of Events • Methods of measuring EEG rhythms. EEG rhythms, waves and transients. Coherent analysis of EEG channels. **LAB -** Electrocardiogram: Signal of Cardiovascular System **SEMINAR:** Technical parameters of the most frequently used bio potentials in medical diagnostics	
5	[1] Ch.3, p. 104-107, 198 [1] Ch.10 p.197-202	**LECTURE:** Noises. Sources of noise. • Natural and artificial noises. • Random noise. Noise in event-related potentials. • High-frequency noise in the ECG. **LAB -** Electroencephalogram, EEG Frequency Spectrum	
6	[1] Ch.3, p. 143-215 [1] Ch.12 p.237-242 [1] Ch.3 p.110, [2] Ch.3 p.47-61	**LECTURE:** Filtering for Removal of Artefacts • Basic concepts of filtering electrical signals. • Sources and types of noise that distort measurement signals. • Types of filters, analogue and digital. • Various filter characteristics. • Circuitry of analogue filters. • Adaptive filters. **LAB -** Blood Pressure, Electrooculogram, Respiratory Signals **SEMINAR:** Types and amplitude-frequency characteristics of electronic filters	
7	[1] Ch. 5, p. 295-327	**LECTURE:** Signal waveform analysis • Analysis of the ECG waveform and its relationship with the muscles of the object of study. Phonocardiogram signals.	

	[2] Ch.1, p.7-9	• Blood pressure signals. • Analysis of respiratory activity signals. **LAB -** Processing and Transformation of Signals	
8	[1] Ch. 3, p. 133-143 [3] Ch.2,4 p.63; 117 [1] Ch.1 p.72-78	**LECTURE:** Fourier transform. • Properties of the Fourier transform. • Informative significance of the Fourier transform. • Fourier transform methods. **LAB -** Operational Amplifier Internals. Basic Op Amp Circuits **SEMINAR:** Visual comparison of various diagnostic bio potentials	Include Midterm exam.
9	[1] Ch. 6, p. 360-385 [3] Ch.6 p.202-210	**LECTURE:** Spectral analysis of signals • Spectral analysis of EEG signals • Spectral analysis of EEG signals. **LAB -** Instrumentation Amplifiers	
10	[1] Ch.4, p. 249-255 [2] Ch.2 p.15-22 [2] Ch.6 -.102	**LECTURE:** Correlation analysis of signals • Correlation analysis of signals. **LAB -** Fourier Transform **SEMINAR:** Fractals in biomedical research	
11	[1] Ch.5, p. 338-343 [2] Ch.2 p.33-60	**LECTURE:** Fractals in nature • Fractal dimension. • Fractal analysis of physiological signals. • Fractal structure of the lungs of the respiratory system. • Fractal analysis of EMG signals. **LAB -** Filter Design, Ideal High-Pass and Low-Pass Filters.	
12	[1] Ch. 6, p. 349-378 [3] Ch.11 p.435-487 [1] Ch.6 p.380-390	**LECTURE:** Frequency-domain Characterization • Frequency analysis. • The periodogram. Spectral power ratios. • Fractal analysis of segments of Vibro-acoustography (VAG) signals. **LAB -** Active Filters **SEMINAR:** Spectral analysis and its informativeness in measuring bio potentials	
13	[1] Ch. 8, p. 469-475, 497 [3] Ch.12.p.503-544 [3] Ch.12 p.503-547	**LECTURE:** Analysis of Nonstationary and Multicomponent Signals • EEG rhythms and waves. • Independent component analysis. • Application Adaptive Filters. **LAB -** Analog-to-Digital-to-Analog Conversion, The Sampling Theorem. **SEMINAR:** Types of ADCs and DACs and their applications	
14	[1] Ch. 9, p. 571-606 [3] Ch.9.p.344-387 [2] Ch.7 p.140-150	**LECTURE:** Pattern Classification and Diagnostic Decision • AI and Neural Networks. • Measures of Diagnostic Accuracy and Cost. • Reliability of Features, Classifiers, and Decisions. **LAB -** Oscillators and Frequency Generators **SEMINAR:** Architecture and varieties of Neural Networks	
15	[1] Ch. 8, p.508-524 [2] Ch.7.p.140-149	**LECTURE:** Visualization measurement signals • Methods of visualization of measurement information. • Wavelets and Time-frequency Analysis. **LAB -** 7 Neural Networks, MATLAB® for Neural Networks	
16			Final exam

Recommended Sources:

TEXTBOOK(S)

1. BIOMEDICAL SIGNAL ANALYSIS. IEEE Press Editorial Board. Tariq Samad, Editor in Chief. Rangaraj M. Rangayyan. 2015, 707p.
2. Biomedical Signal and Image Processing. Kayvan Najarian and Robert Splinter. Taylor & Francis Group, LLC. 2012. 412p.
3. Operational Amplifiers & Linear Integrated Circuits. Theory and Application. James M. Fiore. 2021. 589p.

Assessment

Attendance	0%	At least 75% class attendance is compulsory
Presentation	20%	
Seminars	0%	
Midterm Exam	30%	Written Exam
Final Exam	50%	Written-Exam
Total	100%	

Assessment Criteria
Final grades are determined according to the Academic Regulations of ASOIU for undergraduate studies

Course Policies

- Attendance of the course is mandatory.
- Late assignments will not be accepted unless an agreement is reached with the lecturer.
- Students cannot use calculators during the exam.
- 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	**14**	**3**	**42**
Presentation	1	9	9
Tutorials	14	1	14
Midterm Examination	1	3	3
Preparation for midterm exam	1	9	9
Final Examination	1	3	3
Preparation for final exam	1	18	18
Self-study	14	4	56
Total Workload			**150**
Total Workload/30(h)			**150/30**
ECTS Credit of the Course			**5**