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

Course Unit Title	**Digital signals processing**
Course Unit Code	VTES-B03-1
Type of Course Unit	Elective
Level of Course Unit	3rd year INEN program
National Credits	
Number of ECTS Credits Allocated	9
Theoretical (hour/week)	2
Practice (hour/week)	2
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:

The course "Digital Signal Processing" studies the general properties of signals and their parameters, methods for converting continuous signals into discrete ones, discretization and quantization of analogue signals. Measurement of signal parameters, decomposition of complex signals into elementary signals by Fourier transform, spectral, correlation and other types of signal analysis, algorithms for processing digital signals. Calculation and design of various electronic filters. In practical classes, they master the skills of modelling simple electronic devices in the MULTISIM software environment. In the MATLAB software environment, they master the skills of using algorithms and programs for processing and visualizing time series.

Objectives of the Course:

The objective of the course is to familiarize students with modern methods, algorithms, software and circuitry used for digital processing, transformation and visualization of electrical signals. During the training, students in practical classes master the skills of converting, processing and filtering signals using electronic devices designed by them, become familiar with the operating principle and designs of Analog-Digital and Digital-Analog converters.

Learning Outcomes:

At the end of the course the student will be able to		Assessment
1	Have knowledge of methods for processing measuring electrical signals of various natures;	1, 3
2	Know methods for converting an analog signal into a digital code and digital codes into an analog signal:	1, 3
3	Be able to process primary measuring information using amplifiers, apply various designs of electronic filters to clean up noisy signals;	1, 3
4	Have knowledge and experience in analyzing complex signals based on Fourier transforms, apply spectral and correlation analysis to study measuring signals;	1, 3
5	Create simple simulation models of measuring instruments using the MULTISIM program and analyze the results of measurements and modeling using the MATLAB program.	1, 3

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

Course's Contribution to Program

		CL
1	Ability to distinguish between electrical signals of various natures, using knowledge of physics, chemistry, radio electronics and features of measuring equipment.	3
2	Ability to conduct 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 industrial and scientific practice.	1

5	Ability to use various algorithms for electronic devices and devices to perform design tasks and solve these problems in measuring equipment, as well as the ability to eliminate malfunctions that may occur in electronic 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.1-2 [1] Ch.1 p.4, 12 [3] Ch.2, p.44	**LECTURE:** Basic concepts of digital signal processing. Basic Digital Signal Processing Examples in Block Diagrams. **LAB -** Digital Signal Processing Applications. Signal Frequency (Spectrum) Analysis **SEMINAR:** Digital signals and systems	
2	[1], Ch,2, p.13-20; [2] Ch.3, p.21-30 [3] Ch.1, p.3-7 [3] Ch.1, p.9-10	**LECTURE:** Signal sampling and quantization. Nyquist Sampling Rule. Sampling of Continuous Signal. Quantization. Signal Reconstruction. **LAB -** Sampling, quantization and encoding of continuous signals **SEMINAR:** Data converters	
3	[2] Ch.7, p. 65-74 [1] Ch.2 p.20-24 [3] Ch.6, p.239-243	**LECTURE:** Decimation and Interpolation. Decimation. Interpolation. Resampling by Noninteger Value. **LAB –** Signal Reconstruction **SEMINAR:** Filtering signals. adaptive filtering	
4	[2], Ch.9, p. 83-87 [4] Ch.2, p.63-80 [1] Ch.4, p.91-101; [3] Ch.2, p.65	**LECTURE:** Complex Modulation and Demodulation **LAB -** Operational Amplifiers **SEMINAR:** Fourier Transform signals	
5	[1] Ch.4, p. 91-128 [4] Ch.3, p.85-142 [3] Ch.5, p.198-209	**LECTURE:** Discrete Fourier transform and signal spectrum. Discrete Fourier Transform. Fourier Series Coefficients of Periodic Digital Signals. Fast Fourier Transform. **LAB -** Basic Operational Amplifiers circuits **SEMINAR:** Discrete Fourier Transform. Fast Fourier Transform	
6	[1] Ch.6, p. 173-217 [4] Ch.5, p.156-179 [3] Ch.5, p.214-221	**LECTURE** Digital signal processing systems, basic filtering types, and digital filter realizations. Basic Types of Filtering. Realization of Digital Filters. Bandpass Filtering of Speech. **LAB -** Practical limitation of Operational Amplifiers **SEMINAR:** Spectral analysis signals	
7	[1] Ch. 7, p. 229-304 [2] Ch.5, p.41-52 [4] Ch.6, p.201-237 [1] Ch.2. p.35-46	**LECTURE:** Finite Impulse Respond (FIR) filters **LAB -** Specialized Operational Amplifiers **SEMINAR:** Principles of Analog-to-Digital Conversion	
8	[1] Ch. 8, p. 316-404 [2] Ch.8, p.75-82 [4] Ch.9, p.344-385 [2] Ch.2. p.35-46	**LECTURE:** Infinity Impulse Respond (IIR) filters. **LAB -** Oscillators and frequency generators on the base of OA. **SEMINAR:** Principles of Digital–to-Analog Conversion	Include Midterm exam.
9	[2] Ch.23, p.297-302 [1] Ch.3, p.63; [3] Ch.7, p.283-286 [3] Ch.9, p.330-350	**LECTURE:** Introduction to Video Processing. Color Spaces. Interlacing. Deinterlacing. Image Resolution and Bandwidth. **LAB –** Generation of digital signals **SEMINAR:** Speech signals processing	

10	[1] Ch.13, p.650-714 [2] Ch.23, p.297-307 [3] Ch.7, p.288-290 [1] Ch.14, p.707-730 [3] Ch. 1, p.10-13	**LECTURE:** Image processing basics **LAB -** Noise generators **SEMINAR:** Digital Signal Processors	
11	[2] Ch.25, p.329-335 [4] Ch.11, p.435-487 [3] Ch.11, p.430-436	**LECTURE:** Image and Video Compression Fundamentals. Baseline JPEG. Scaling. Quantization Tables. Entropy Coding. JPEG Extensions. Video Compression Basics **LAB –** Active filters on the base of OA **SEMINAR:** Digital Image Processing	
12	[1] Ch.14, p.727-781 [4] Ch.12, p.503-547 [3] Ch.11, p.431-436	**LECTURE:** Hardware and software for digital signal processors **LAB -** Analog-to-Digital converters. Sampling. **SEMINAR:** Digital image systems	
13	[2] Ch.27, p.361-370 [4] Ch.12, p.503-547 [3] Ch.11, p.440-447	**LECTURE:** Implementation Using Digital Signal Processors **LAB -** Digital-to-Analog converters **SEMINAR:** Image filtering	
14	[2] Ch.28, p.371-383 [2] Ch.29, p.387-392 [4] Ch.10, p.426-428 [2] Ch.25, p.329-346	**LECTURE:** Implementation Using FPGAs and GPUs **LAB -** Useful Circuits Based on Operational Amplifiers **SEMINAR:** Image and Video compressing	
15	[2] Ch.26, p.347-358 [4] Ch.10, p.423-425 [2] Ch.26, p.347-353	**LECTURE:** Introduction to Machine Learning **LAB –** Analog computers for modelling physical systems. **SEMINAR:** Neural Networks architecture and layers	
16			Final exam

Recommended Sources:
TEXTBOOK(S)

1. Digital Signal Processing. Lizhe Tan, Jean Jiang. Academic Press is an imprint of Elsevier. 2019. 902p.
2. Digital Signal Processing 101. Michael Parker. Intel Corporation. 2017. 434p.
3. Real-Time Digital Signal Processing Fundamentals, Implementations and Applications. Sen M. Kuo, Bob H. Lee and Wenshun Tian. Wiley. 2013. 566p.
4. 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**