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

Course Unit Title	**Metrology Aspect of Measurement Devices**
Course Unit Code	VTES-B01-2
Type of Course Unit	Elective
Level of Course Unit	1 st year INEN program
National Credits	10
Number of ECTS Credits Allocated	10
Theoretical (hour/week)	2
Practice (hour/week)	1
Laboratory (hour/week)	2
Year of Study	2
Semester when the course unit is delivered	4
Course Coordinator	Rashid Mammadov
Name of Lecturer (s)	Rashid Mammadov
Name of Assistant (s)	-
Mode of Delivery	Face to Face
Language of Instruction	English
Prerequisites	-
Recommended Optional Programme Components	-

Course description:

This course provides an in-depth exploration of the metrological principles underlying the design, operation, and calibration of measurement devices. It covers fundamental concepts of measurement accuracy, precision, repeatability, and reproducibility, ensuring a strong foundation in applied metrology for various scientific and industrial applications.

Objectives of the Course:

The main objective and purpose of the course are to equip students with essential metrology knowledge and practical skills to ensure the accuracy, reliability, and compliance of measurement devices. By the end of the course, participants will be able to understand fundamental metrological principles such as accuracy, precision, repeatability, and traceability. Analyze the performance of measurement devices and assess their metrological characteristics.

Learning Outcomes

At the end of the course the student will be able to		Assessment
1.	Understand the fundamental principles of metrology and its significance in measurement devices.	1,3
2.	Identify and explain various types of measurement devices and their applications in different fields.	1,2,3
3.	Analyze the errors and uncertainties in measurement systems and evaluate methods to minimize them.	2,3
4.	Perform calibrations and maintenance of measurement instruments in accordance with international standards	2,3
5.	Interpret metrological standards and apply them in the design and evaluation of measurement systems	1,3
6.	Apply knowledge of metrology in real-world applications through laboratory experiments.	1,3

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

Course's Contribution to Program

		CL
1	Ability to apply metrological principles to analyze and solve complex measurement-related problems in engineering and science.	4
2	Develop skills to identify and evaluate uncertainties and errors in measurement systems and apply corrective measures to ensure accuracy and precision.	2
3	Acquire hands-on experience in the calibration and maintenance of measurement devices, enhancing practical understanding and technical skills in laboratory environments.	1
4	Demonstrate knowledge of international metrology standards (such as ISO and IEC) and apply them in real-world contexts, ensuring compliance with legal and technical regulations.	5
5	Ability to design, implement, and evaluate measurement systems using modern techniques, methodologies, and digital tools.	4
6	Gain insight into advanced and emerging trends in metrology, including automation and digitalization of measurement systems, to stay updated with industry advancements.	4
7	Develop problem-solving and critical-thinking skills through participation in seminars, discussions, and case studies related to measurement technologies and metrological challenges.	3
8	Strengthen communication skills by presenting laboratory findings, participating in seminars, and collaborating on group projects to discuss metrological issues and solutions.	

9	Understand and apply ethical considerations, accuracy requirements, and precision standards in measurement systems, particularly in the calibration and certification of instruments.	2
10	Ability to manage and document calibration processes in alignment with industry standards, ensuring traceability, accuracy, and the highest level of quality in measurement results.	4

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

Course Contents

Week	Chapter	Topics	Exam
1	Ch 1	**LECTURE**: Introduction to Metrology. Overview of metrology, history, and importance. International System of units (SI) and its applications in measurement **LAB**-Discussion on the historical development and global impact of metrology.	
2	Ch 1(3)	**LECTURE**: Classification of Measurement Devices. Types of measurement devices (length, mass, temperature, etc.). **LAB**- Key components and functions of each device **SEMINAR**: Case study on the selection of appropriate measurement devices for specific industrial applications.	
3	Ch 3, Ch 8, Ch 12.	**LECTURE**: Measurement Errors. Types of errors (systematic and random errors). Sources of measurement errors and their impact on results **LAB-** Real-world examples of common measurement errors and their mitigation strategies.	
4	Ch 9, Ch 13, Ch 15	**LECTURE**: Uncertainty in Measurements. Introduction to uncertainty analysis. **LAB-** Calculation of measurement uncertainty using statistical methods **SEMINAR**:Hands-on exercise calculating measurement uncertainty in laboratory experiments	
5	Ch 17	**LECTURE**: Calibration of Measurement Devices. Importance of calibration in metrology .Calibration procedures and intervals for different devices **LAB** Calibration of temperature sensors and pressure gauges	
6	Ch 23, Ch 24	**LECTURE**: Metrological Traceability. Concept of traceability in measurements. **LAB** Establishing and maintaining traceability in calibration processes **SEMINAR**: Group discussion on the significance of traceability in national and international standards.	
7	Ch 26	**LECTURE**: International Metrology Standards. **LAB**- Exploration of global metrology organizations and their role in standardization.	Midterm
8	Ch 27	**LECTURE**: National and international regulations for measurement devices **LAB**-Application of modern technology in metrology	
9	Ch 18 (1-4)	**LECTURE**: Legal Metrology and Regulations. **Understanding** legal metrology and its impact on trade and industry **SEMINAR**: Case study on the legal implications of non-compliance with metrological standards in industry.	
10	Ch 19 (6,7)	**LECTURE**: Hands-on calibration of various devices Error analysis in practical calibration exercises **LAB**-Calibration of electrical measuring devices (voltmeter, ammeter) and analysis of results.	
11	Ch 25, Ch 18	**LECTURE**: Routine maintenance procedures for measurement instruments **LAB**- Troubleshooting and common issues in measurement devices **SEMINAR**: Maintenance and troubleshooting of malfunctioning instruments.	
12	Ch 30	**LECTURE**: Advanced Measurement Techniques Introduction to automated and digital measurement systems **LAB** Case studies on the integration of automated systems in modern laboratories.	
13	Ch 31	**LECTURE**: Future Trends in Metrology. **LAB**- The role of automation, AI, and IoT in measurement systems **SEMINAR**: Discussion on the future of digital metrology and the role of artificial intelligence.	
14	Ch 43	**LECTURE**:Error reduction and device optimization **LAB**- Group projects on solving real-world metrological problems through	

		innovative solutions	
15	Ch 34	**LECTURE**: Maintenance of Measurement Devices **LAB**- Exploration of emerging technologies and trends in the field of metrology **SEMINAR**: Overview of key metrological standards (ISO, IEC).	
16			Final exam

Recommended Sources

TEXTBOOK(S)

1. Bureau International des Poids et Mesures (BIPM).The International System of Units (SI) – Latest Edition.
2. JCGM 100:2008 (GUM - Guide to the Expression of Uncertainty in Measurement).
3. Fluke Calibration.Calibration: Philosophy in Practice – 2nd Edition, by Fluke Corporation.
4. M. Kochsiek & M. Knaupp.Handbook of Metrology – Springer.
5. David J. Whitehouse.Handbook of Surface and Nanometrology – CRC Press.
6. A. E. Fridman.Introduction to Metrology and Calibration – Springer.
7. ISO/IEC 17025 & ISO/IEC 17043 Standards.

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. works	10%	
Course work	0%	
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

1. Attendance of the course is mandatory.
2. Material presented in the lecture as well as assigned readings will be included in testing.
3. Late assignments will not be accepted unless an agreement is reached with the lecturer.
4. Cheating and plagiarism will not be tolerated.
5. 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 (including midterm)	15	5	75
Presentation	1	10	10
Self-study	15	6	90
Tutorials	15	6	90
Midterm Examination	1	3	3
Preparation for midterm exam	1	12	12
Final Examination	1	3	3
Preparation for final exam	1	24	24
Total Workload			**307**
Total Workload/30(h)			**10.23**
ECTS Credit of the Course			**10**