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

Course Unit Title	Applied Metrology and Calibration
Course Unit Code	VTES-B02-2
Type of Course Unit	Elective
Level of Course Unit	1 st year INEN program
National Credits	9
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	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 a comprehensive understanding of applied metrology and calibration, focusing on the principles, methodologies, and best practices used in measurement science. It covers the fundamental concepts of metrology, including measurement uncertainty, traceability, and standards, while emphasizing the importance of accuracy, precision, and reliability in various industrial and scientific applications.

Objectives of the Course:

The main objective and purpose of the course are explain the key concepts of measurement science, including accuracy, precision, repeatability, and reproducibility, recognize the importance of metrological traceability and measurement standards and perform calibration of various measuring instruments using internationally recognized methods.

Learning Outcomes

At the end of the course the student will be able to		Assessment
1.	Understand the role of metrology in ensuring the accuracy and precision of measurements in various industries.	1,3
2.	Perform and evaluate the calibration of various types of measurement devices.	1,2,3
3.	Analyze measurement errors and uncertainty in calibration processes.	2,3
4.	Apply metrological principles and standards in the design and maintenance of calibration systems.	2,3
5.	Conduct calibration of different measurement instruments in compliance with international standards.	1,3
6.	Utilize modern calibration techniques and technologies, including automation, for real-world applications.	1,3

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

Course's Contribution to Program

		CL
1	Apply metrological principles to analyse and solve calibration-related issues in engineering and industry.	4
2	Develop skills to minimize errors and uncertainty in calibration processes and ensure accuracy and precision in measurements.	2
3	Gain practical experience in calibrating and maintaining a variety of measurement instruments.	1
4	Demonstrate knowledge of international calibration standards and apply them in compliance with legal and technical regulations.	5
5	Design and evaluate calibration systems using modern techniques and methodologies.	4
6	Stay updated on emerging trends in metrology and calibration technologies and apply them in real-world contexts.	3
7	Develop problem-solving and critical thinking skills through seminars, discussions, and case studies related to calibration challenges.	3
8	Strengthen communication and teamwork skills by presenting laboratory findings, collaborating on group projects, and discussing calibration problems and solutions.	2
9	Understand and apply ethical considerations, accuracy requirements, and precision standards in	3

	calibration systems.	
10	Ability to manage calibration documentation, including certificates and traceability records, ensuring high-quality results in industrial applications.	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 Applied Metrology. The role of applied metrology in industrial applications. **LAB**-Development of Air Flow Data Acquisition Syste **SEMINAR**: Discussion on the importance of metrology in quality assurance and industrial processes.	
2	Ch 1(4)	**LECTURE**: Classification of Calibration Methods. Primary, secondary, and working standards. **LAB**- Types of calibration (length, mass, temperature, pressure, etc.) **SEMINAR**: Case study on different calibration methods used in various industries.	
3	Ch 2, Ch 5, Ch 7.	**LECTURE**: Measurement Errors in Calibration. Types of errors: systematic, random, and gross errors. **LAB-** Effects of errors on calibration results **SEMINAR**: Real-world examples of measurement errors and their mitigation in calibration.	
4	Ch 6, Ch 10, Ch 11	**LECTURE**: Uncertainty Analysis in Calibration. Introduction to uncertainty in calibration processes **LAB-** Effects of errors on calibration results **SEMINAR**:Exercise on uncertainty calculation for calibration processes.	
5	Ch 14	**LECTURE**: Calibration of Measurement Devices. **LAB**- Documentation requirements and traceability **SEMINAR**:Exercise on uncertainty calculation for calibration processes.	
6	Ch 20, Ch 21	**LECTURE**: International Calibration Standards. Key standards for calibration (ISO, IEC, OIML) **LAB** .Legal and regulatory frameworks **SEMINAR**: Discussion on the impact of international standards on calibration practices	
7	Ch 22	**LECTURE**: Traceability in Calibration. **LAB**- Establishing and maintaining traceability in calibration **SEMINAR**: Case study on traceability in calibration laboratories..	Midterm
8	Ch 23	**LECTURE**: Calibration certificates and documentation **LAB**-Examples of solving problems on thermodynamics **SEMINAR**: Procedures for calibrating different types of measurement instruments	
9	Ch 15 (1-5)	**LECTURE**: Error Propagation in Calibration. **LAB**-Methods to calculate and control error propagation in calibration processes **SEMINAR**: Error analysis and propagation in multi-step calibration processes	
10	Ch 15 (6,7)	**LECTURE**: Laboratory Calibration Exercises Practical calibration of various instruments. **LAB**-Documentation and error analysis of results **SEMINAR**: Calibration of flow meters and torque measuring devices	
11	Ch 16, Ch 18	**LECTURE**: Maintenance of Calibration Instruments **LAB**- Calibration interval determination and equipment life cycle **SEMINAR**: Hands-on maintenance and troubleshooting of common calibration devices.	
12	Ch 37	**LECTURE**: Advanced Calibration Techniques Automation in calibration processes **LAB**- Use of digital technologies and software in calibration **SEMINAR**: Discussion on the use of automation and AI in modern calibration systems.	
13	Ch 38	**LECTURE**: Future Trends in Metrology and Calibration. **LAB**- The role of digital transformation and AI in metrology **SEMINAR**: Group project on the future of calibration and its role in industrial development.	

14	Ch 40	**LECTURE**:Problem-solving sessions focusing on real-world calibration issues **LAB**- Case study analysis of calibration issues in high-precision environments. **SEMINAR**: Group discussion on calibration challenges and solutions	
15	Ch 44	**LECTURE**: Practical application in complex measurement systems **LAB**- Exploration of emerging technologies in calibration **SEMINAR**: Routine maintenance and troubleshooting of calibration equipment	
16			Final exam

Recommended Sources

TEXTBOOK(S)

1. Bentley, J. P. – Principles of Measurement Systems, 4th Edition, Pearson, 2005.
2. BIPM (International Bureau of Weights and Measures) – The International System of Units (SI), Latest Edition.
3. Doebelin, E. O. & Manik, D. N. – Measurement Systems: Application and Design, 6th Edition, McGraw-Hill, 2017.
4. JCGM 100:2008 – Evaluation of Measurement Data – Guide to the Expression of Uncertainty in Measurement (GUM), Joint Committee for Guides in Metrology.
5. OIML (International Organization of Legal Metrology) – International Vocabulary of Metrology (VIM), 3rd Edition, 2012.
6. Klaassen, K. B. – Electronic Measurement and Instrumentation, Cambridge University Press, 1996.
7. White, D. R., & Saunders, P. – Guide to Temperature Measurement, National Measurement Institute, 2010.
8. Biemann, K. – Metrology and Calibration Handbook, Springer, 2012.
9. Grattan, K. T. V., & Sun, T. – Metrology and Measurement Systems, Springer, 2017.
10. Fluke Calibration – Calibration: Philosophy in Practice, 2nd Edition, Fluke Corporation, 1994

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	6	90
Presentation	1	10	10
Self-study	15	5	75
Tutorials	15	4	60
Midterm Examination	1	3	3
Preparation for midterm exam	1	10	10
Final Examination	1	3	3
Preparation for final exam	1	20	20
Total Workload			**271**
Total Workload/30(h)			**9,03**
ECTS Credit of the Course			**9**