

MEASUREMENTS FOR INDUSTRIAL SUSTAINABILITY AND SAFETY



MEASURE



MONITOR



PROTECT



IMPROVE



Measurements for industrial sustainability and safety

Course Objectives:

1

Provide basic knowledge of Measurement Theory

2

Provide specific knowledge of using sensors, transducers and measuring instruments

3

Understanding how to design measurement chain for industry and the environment

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Course Outline:

Part I Measurement Theory

Part II Instruments and Signal Manipulation

Part III Sensors and transducers

Course Outline:

Part I: Measurement Theory

1. SYSTEMS OF UNITS OF MEASUREMENT

Introduction, concepts of measure and measurement, physical quantities and their dimensions, dimensional equations, systems of units with particular reference to the International System of Units (SI). Change of units and conversion factor.

2. METROLOGICAL PROPERTIES OF INSTRUMENTS

Measurement chain (sensor, signal processor, indicating instrument), types of instruments. Metrological properties: measurement span, sensitivity, accuracy, stiffness, dynamic response (speed of response). Zero-, first-, and second-order systems. Statistical data analysis: frequency and probability; normal distribution; mean and standard deviation. Error theory, standard error, error propagation.

Course Outline:

Part II: Signal Analysis

3. MEASUREMENT SIGNAL PROCESSING

Conversion between voltage and current measured signals. Analog signal processors: rectifier diode, passive filters, operational amplifier (open-loop and closed-loop), active filters, Wheatstone bridges (WB).

4. DIGITAL INSTRUMENTS AND DIGITAL MEASUREMENT SYSTEMS

Electronic counters, time measurement. Signal sampling, A/D conversion, aliasing, and data acquisition systems.

Course Outline:

Part III: Sensors and transducers

5. LENGTH AND DISPLACEMENT MEASUREMENT

Overview of workshop metrology (calipers and micrometers), electrical displacement transducers (resistive, capacitive, and inductive). Linear Variable Displacement Transducer (LVDT), Encoders.

6. STRAIN MEASUREMENT

Electrical resistance strain gauges, operating principles and application techniques, thermal effect compensation, measurement of simple stress states (tension, bending). Strain gauge data acquisition units. Fiber optic sensors.

Course Outline:

Part III: Sensors and transducers

7. MEASUREMENT OF MASS, FORCE AND PRESSURE

Scales and dynamometers, bending and compression load cells. Liquid manometers, mechanical and electrical pressure gauges. Piezoelectric pressure gauges, piezoresistive transducers.

8. TEMPERATURE MEASUREMENT

Absolute temperature scale. Overview of thermometer types: electrical thermometers, platinum resistance thermometers (RTDs), thermistors, thermocouples.

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Course Outline:

Part III: Sensors and transducers

9. VELOCITY MEASUREMENT

Linear and angular velocity, fluid velocity measurement, Bernoulli's equation and Pitot tube.

10. FLOW RATE MEASUREMENT

Conservation of flow rate. Venturi meter, Turbine flow meter, rotameter.

Practical lessons

2-3 LABORATORY EXERCISES

Why do measurements?

- Accurate measurements are essential for evaluating environmental impact and sustainability in industrial processes and ecosystems.
- Measurements are crucial for ensuring compliance with environmental regulations and enhancing safety in industrial operations.
- The result of a measurement also has legal implications!

How to perform a high-quality measurement?

- Understand instrument characteristics (metrological properties) to select the best instrument based on the measurement objective.
- Acquire a signal, process it, and convert it to digital.
- Measuring instruments for the main mechanical quantities of interest in the industrial field.

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e-learning platform:

1. All the documentation about course lectures (slides, pdf, lab session texts, etc.) will be available on the specific course page on e-learning (Moodle Sapienza).
2. Look for the course name (Measurements for Industrial and Sustainability and Environmental Safety - MISES) and register to the course with the password.

Bibliography:

1. “Principles of Measurement Systems” by J. P. Bentley and W. G. Duff (Online)
2. “Environmental Instrumentation and Analysis Handbook” by J. H. Lehr and R. D. Down (Online)
3. “Mechanical Measurements” by S. P. Venkateshan (Online)
4. “Instrumentation Reference Book” by W. Boyes (Online)
5. “Measurement and Sensor Systems: A Comprehensive Guide to Principles, Practical Issues and Applications” by A. W. Koch (Online)

Rules for the EXAM:

The exam consists of an **ORAL EXAM** structured as follows:

- Two theoretical questions
- A practical exercise, aimed at testing the ability to apply theoretical concepts to a practical problem.

Each of the three parts accounts for 1/3 of the final grade.

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Exam dates:

1° call:	18	January 2027
2° call:	22	February 2027
3° call:	15	March 2027
4° call:	20	June 2027
5° call:	19	July 2027
6° call:	13	September 2027