UNICUSANO
ROME

Code:	**Credits: 9**
Matter: Sensors and Transducers	
Main language of instruction: Italian	
Other language of instruction: English	

Teaching Staff

Head instructor
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Introduction

1. *Objective of the course :*

In the first part of the course, the subject of measurements in general, the metrological nomenclature and the typical conventions used in the field of measurements are dealt with. The student will learn to read a manual of a sensor, its conditioning equipment, and the calibration certificate. To this end, the static and dynamic characteristics of the instruments are examined in detail, in order to understand the concept of performance and calibration in a dynamic environment. After some rudiments of electrical measurements, we discuss the sensors used for the main physical quantities of interest in industry such as temperature, displacement, speed, acceleration, deformation, force, pressure and flow.
The E-activities to be carried out for the Teaching are proposed in the form of Case Studies and / or Simulations, and are necessary for a deeper understanding of some topics of the Teaching, as well as useful for determining the final vote.
The approach is however such that the student can acquire a method of analysis, and is therefore able to extend to different situations what has been learned for specific conditions.

Objectives

The Teaching starts with references to the static and dynamic characteristics of the instruments, with definitions in the technical and metrological field, of all the main static and dynamic characteristics. The methods for electrical measurements are described, followed by temperature, displacement, speed, acceleration, deformation, force, pressure and flow sensors. The student then has the opportunity to examine the principle of operation of many sensors and transducers in use in industry corresponding to these physical quantities. For each method, the suitable measurement chains and the typical causes of errors and influencing quantities are

discussed. Application examples with discussion of extracts from the technical manuals are always given.

Competencies:

At the end of the course, the student will have demonstrated the ability to:

- describe the operation of methods for measuring temperature, displacement, velocity, acceleration, deformation and force.
- interpret and use the terminology used in metrology and measurement in general.
- identify the most important causes of error for a given transducer and associated measurement chain.
- identify the useful characteristics for the use of an instrument from a technical manual and a calibration certificate.
- determine the most suitable measurement chain for a given temperature, displacement, velocity, acceleration, strain or force transducer.
- illustrate and describe topics related to measurement techniques to specialists and non-specialists.
- to understand, with a good degree of autonomy, issues in the field of measurement, even if not directly addressed in teaching.

Syllabus

- M10 Module - Measurement Basics

This module provides the student with the basic concepts to proceed with the study of methods and measuring instruments. Reference standards for the metrological definitions used in the following modules are also introduced.
The general concept of transducer and sensor as multi-input and multi-output object and the design criteria of a measurement chain are described.
It concludes with references to the international SI system, and to the practical systems, CGS, MKS and British.

- Module M01 - Static Characteristics

In this module, the student is introduced to the basic metrological terms used to characterize the performance of instruments in the static environment. The definitions of the UNI standard and the V.I.M. vocabulary are examined one by one and compared.
Characteristics such as sensitivity, linearity, hysteresis, and the various definitions of the measurement range are reported and explained in detail. The difference between repeatability and reproducibility, and between drift and stability, is explained. Particular attention is paid to the description of the influence quantities. Finally, it is explained how to read a calibration certificate.

- Module M06 - Dynamic Characteristics

This module illustrates the characteristics used to classify and model the performance of instruments in a dynamic environment. After a brief general introduction on dynamic linear systems, the basic parameters associated with the frequency response of the instruments are described. The calibration and modelling techniques of first and second order systems, using mechanical and electrical equivalents, are explained below.

- Module M12 - Temperature Measurement

In this module, students have the opportunity to learn about the most commonly used temperature measurement methods in industry. After a brief introduction to thermometric scales, the module illustrates fixed points, bulb, metal resistance and semiconductor transducers, thermocouples and integrated circuit sensors. For each instrument, the correct method of use, the measurement chain and any signal conditioning are examined. The main metrological characteristics for each type of transducer are described, with particular attention to the influence quantities and causes of errors. Commercial examples of temperature sensors and control instruments are often reported and illustrated in detail, with discussion of the technical documentation.

- Module M13 - Displacement, velocity and acceleration Measurement

In this module, the student has the opportunity to learn about the methods of measurement of cinematic quantities most used in industry. The first methodology concerns displacement and velocity measurements, therefore resistive (potentiometers), inductive (LVDT), ultrasonic (piezoelectric), capacitive, strain gauge, laser, eddy current and digital (encoder) displacement sensors are illustrated. The second methodology concerns seismic or inertial sensors. The student then has the opportunity to learn how to operate a displacement and acceleration sensor used, respectively, as vibrometers or accelerometers.

The third methodology concerns strain measurements, limited to the description of electrical resistance, piezoresistance and piezoelectric element strain gages. The main metrological characteristics for each methodology, the influence quantities and the causes of errors are always underlined. Some commercial examples of sensors are also given, with discussion of the technical documentation.

- Module M14 - Force Measurement

This module illustrates the most commonly used force measurement methods in industry. After a brief introduction to load cells, in terms of metrological characteristics, design and general design criteria, the various types of spring elements made up of force sensors are discussed. Starting with the description of the column load cells, we move on to the bending and shear load cells, with an illustration of the uncouplers for the compensation of transverse loads. In addition, the module describe the operation of piezoelectric load cells and other less common devices such as those with vibrating element, Hall effect and fiber optic. Particular attention is paid

to the operation of torque transducers, and to the transmission of the torque signal on rotating shafts. Finally, the static and dynamic calibration of the load cells is described. In the module, the transducers are always described, showing the influence quantities and the causes of errors. In addition, commercial examples of load cells and torque transducers are always reported and illustrated in detail, with discussion of the technical documentation.

Evaluation system and criteria

The verification of the achievement of the Learning Results is carried out through the evaluation of the E-activities and the final Exam. The final grade is the sum of the scores obtained by the two E-activities and the final exam.

E-tivity Evaluation

Both E-activities are mandatory, and both E tivities must receive at least sufficient evaluation, otherwise the final exam will not be evaluated.

E-activities are evaluated differently depending on how you follow the Teaching:

- Autonomous Mode: each E tivity is rated at most 3 points, for a total maximum of 6 points.
- Guided mode: each E tivity is rated a maximum of 4 points, for a maximum total of 8 points

E-tivity evaluates all of the Learning Outcomes listed for Teaching, particularly those related to Learning Ability.

Final exam Evaluation

The final exam is divided into three parts:

- Part 1 (max 12 points): question about static characteristics or temperature measurements
- Part 2 (max 12 points): question on one of the subjects not dealt with in the previous question
- E-tivity Recovery (max 3+3 points): if you do not get 3 points by an E-tivity, you can recover points by answering theoretical questions and/or quick quizzes about the whole program.

The final exam evaluates all the Learning Results listed for Teaching, except those related to Learning Ability.

Bibliography and resources

- Teaching materials by the teacher

Recommended bibliography:

- Instruments and methods of measurement. 2008 by Ernest O. Doebelin (Author), edited by A. Cigada and M. Gasparetto. McGraw-Hill
- Basics of mechanical and thermal measurements. 2008 by Rinaldo Vallascas. Hoepli