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# Machinery experimentation

## Finalità

The main goal of the course is to impart to the student the principles of measurements and machines testing. Starting from a functional description of general measuring systems, the course gives the basics for the analysis of different systems, in both steady and unsteady conditions. Moreover, many instruments widely used for machine testing are presented. Few lessons are focused on specific examples of machine testing.

## Programma

### **General concepts**

Fundamental standards in measurements system: basic and derived units. International System of Units. Description of the real phenomena through models as a basic method for measurements.

### **Instruments accuracy**

Fundamentals and definition of accuracy. Repeatability, precision and bias. Instrument uncertainty and confidence level. Static characteristic and calibration. Evaluation of repeatability with “a priori” and “a posteriori” techniques. Normal distribution, Acceptance criteria and “chi square test”. Combination of component errors in overall system accuracy calculation; the Kline-McClintock formula. Experimental evaluation of combined error. Total error for a measurement system.

### **Measurement systems**

Classification of measurement systems as function of their target. Functional elements of an instruments. Definition of transducer. Active or passive transducers. Desired and interfering inputs. Loading effects. Methods of correction of interfering and modifying inputs.

### **Generalized performance characteristics of instruments**

Introduction. Static and dynamic characteristic  
Static sensivity and linearity.  
Generalized mathematical model of measurement system.  
Operational transfer function  
Sinusoidal transfer function  
Zero, first and second order instruments. Dead time elements.  
Step, ramp, impulse responses  
Generic response of a general form of instruments  
Frequency spectra of response.  
Bode and Nyquist diagrams  
Experimental determination of measurement system parameter.

### **Pressure Measurement**

Manometers. Elastic transducer. Liquid and differential manometers.  
High pressure and low pressure measurement.  
Indicators.  
Pressure Transducers, piezoelectric transducer.  
Dynamic effects of volumes and connecting tubing.  
Total and static pressure measurement

### **Temperature measurement**

Standard and calibration.  
Thermal expansion methods, bimetallic methods, Liquid in gas thermometers. Pressure thermometers.  
Thermocouples: reference junction consideration, considerations and techniques. Electrical-resistance sensors. Thermistors.  
Radiation methods. Pyrometers.  
Temperature-measuring problems in flowing fluids.

### **Flow measurement**

Qualitative methods. Flow visualization.  
Local flow velocity measurements. Pitot static tube, yaw tube.  
Film anemometers. Brief introduction to LDV techniques.  
Gross volume and mass flow rates measurements.  
Obstruction meters. Rotameters. Turbine meters. Positive displacement meters.  
Density measurement. Direct mass flow-meters

## Attività d'esercitazione

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Several experiments are discussed and carried out after the first part of the course.

The students will perform tests on two sample systems (small fan and centrifugal pumps), using the facilities of the laboratories of the Industrial Engineering Department.

The course includes also a visit to an industrial test bench for hydraulic pumps and motors.

#### Modalità d'esame

Oral test and, eventually, presentation or discussion of the results of performed tests.

#### Testi consigliati

1. Angrilli, F., 1996, Appunti di Misure Meccaniche e Termiche Ed. CUSL Nuova Vita, Padova
2. Doebelin, E. O., 1990, Measurement System – Application and Design 4th edition, McGraw-Hill.
3. Minelli, G. 1974, Misure Meccaniche, Ed. Patron