# UNIVERSITÀ DEGLI STUDI DI PALERMO

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| **DEPARTMENT** | Ingegneria |
| **ACADEMIC YEAR** | 2021/2022 |
| **BACHELOR'S DEGREE (BSC)** | MECHANICAL ENGINEERING |
| **SUBJECT** | MECHANIC AND THERMAL MEASUREMENTS |
| **TYPE OF EDUCATIONAL ACTIVITY** | B |
| **AMBIT** | 50302-Ingegneria meccanica |
| **CODE** | 05269 |
| **SCIENTIFIC SECTOR(S)** | ING-IND/12 |
| **HEAD PROFESSOR(S)** | D'ACQUISTO LEONARDO Professore Ordinario Univ. di PALERMO |
| **OTHER PROFESSOR(S)** | |
| **CREDITS** | 9 |
| **INDIVIDUAL STUDY (Hrs)** | 144 |
| **COURSE ACTIVITY (Hrs)** | 81 |
| **PROPAEDEUTICAL SUBJECTS** | |
| **MUTUALIZATION** | |
| **YEAR** | 3 |
| **TERM (SEMESTER)** | 1° semester |
| **ATTENDANCE** | Not mandatory |
| **EVALUATION** | Out of 30 |
| **TEACHER OFFICE HOURS** | **D'ACQUISTO LEONARDO**<br>Thursday 08:30 10:00 Edificio 8 - stanza docente |

**DOCENTE:** Prof. LEONARDO D'ACQUISTO

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| **PREREQUISITES** | General concepts of mathematical analysis (calculus of derivatives and integrals), General concepts of phisycs (knowledge of main physical quantities, measurement units' systems) . Basic principles of electrotechnology (resistive, inductive and capacitive circuits). |
| **LEARNING OUTCOMES** | Knowledge and understanding The student, at the end of the course, will have knowledge about methodologies to apply and solve effectively the problems of measurement of mechanical and thermal quantities. Applying knowledge and understanding The student will have acquired knowledge, methodologies and the conceptual approach requested to analyze and solve problems related to the identification and selection of measurement techniques fit to the correct measurement of the quantity of interest. Making judgments At the end of the course the student will be able to integrate knowledge and handle complexity, as well as to make judgments based on limited information. Communication skills The student will be able to properly communicate with language skills, both to expert or common level people, its conclusions as well as the underlying knowledge and rationale about issues related to the approach to the definition and development of a measurement process. Learning skills The student will have developed those learning skills that let him to autonomously master issues such as the optimization of the resources used for the purpose of reducing uncertainty associated with the measurement result. |
| **ASSESSMENT METHODS** | Oral exam Evaluation criteria for the oral examination The oral test consists of an interview, in order to check that you have skills and knowledge disciplinary provided by the course; the evaluation is expressed in thirtieths. The questions, both open both semi-structured to test the results of learning provided for, will tend to occur: a) the knowledge captured; b) the processing capacity, c) have adequate display capacity on the course contents. The final evaluation will be formulated according the following graduation of knowledge of the student. Excellent 30-30 and praise, very good knowledge of the topics, excellent properties of language, good analytical ability, the student is able to apply knowledge to effectively solve measurements problems proposed 26-29 Very Good, Good command of the topics, full of language, the student is able to apply knowledge to solve measurements problems proposed 24-25 good, basic understanding of the main topics, discrete properties of language, with limited ability to independently apply the knowledge to the solution of the proposed problems Satisfactory 21-23, has not fully mastered the main teaching subjects but it has the knowledge, satisfactory property language, poor ability to independently apply the knowledge acquired Sufficient 18-20, Minimum basic understanding of the major teaching and technical language issues, very little or no ability to independently apply the knowledge acquired Insufficient, it does not have an acceptable knowledge of the contents of the topics covered in the teaching |
| **EDUCATIONAL OBJECTIVES** | OBJECTIVES OF CORSE The overall aim of the present course is to present the topics of measuring systems as an integrated and coherent subject. Actually, sensors and instruments are of immense importance in a wide variety of applications. The growth in the sophistication of instruments have been particularly significant, however little efforts are posed to the data validation, that is the full exploitation of inaccuracy associated to the collected data. Thus, questions still linger over how to objectively assess: the accuracy, response time, residual life, and other characteristics of employed instrumentation. The Course in Mechanical and Thermal Measurements is intended: to offer practical means to identify them; to assess their consequences; and to help resolve them. Therefore, the aim of the course is to provide a solid foundation for the design of effective measuring systems in Mechanical Engineering and for reaching valid experimental data. |
| **TEACHING METHODS** | Frontal lessons. Classroom exercises and laboratory experiences |
| **SUGGESTED BIBLIOGRAPHY** | - Vallascas R. : Fondamenti di misure meccaniche e termiche Grandezze statiche e sistemi. Editore: HOEPLI , 2008 - ISBN978-8820340711 :<br>- Doebelin, Ernest O. - “Strumenti e metodi di misura” “ II edizione – McGraw-Hill, 2008 - ISBN: 8838664358<br>- Dispense a cura del docente in formato pdf |

# SYLLABUS

| Hrs | Frontal teaching |
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| 25 | Basics of measurements, instruments and measuring systems. Analytical models of instruments' dynamic response<br><br>- Introduction to the evolution of the most widespread systems of measurement units. International system of measurement units and reference standards<br><br>- Types of measuring instrument applications: Observation of processes and operations - Regulation of processes and operations - Experimental investigation in engineering<br><br>- General configuration and operating principles of the measuring instruments: functional elements of an instrument - Active and passive sensors - Analogical or numerical operating method - Compensation or direct reading instruments - Input and output quantities of an instrument - Methods for reducing the effects of influence quantities<br><br>- Generalized operating characteristics of measuring instruments and systems<br>1 - Static characteristics - Measurand, instrument, operator, environment. Resolution. Stability. Interaction with the environment. Repeatability, the limit of the potential of a measurement system. Reproducibility, a concrete assessment of the potential of a measurement system (outline). Accuracy, need for a reference sample. The calibration of an instrument. The traceability of measuring instruments to national standards. Measurement compatibility.<br><br>Typical errors: linearity, hysteresis, inversion, mobility, mobility threshold.<br>Calibration - Repeatability - Accuracy - Systematic error - Sensitivity - Linearity - Threshold value - Resolution - Hysteresis - Dead space - Scale readability - Useful range - Input impedance - Effect of applying the instrument on the quantity to be measured<br><br>2 -Dynamic features: Generalized mathematical model of a measurement system - Transfer function - Zero, one and two order systems and their behavior in the presence of variable input quantities according to step, ramp, impulsive and sinusoidal functions - Graphical representation the dynamic characteristics of a system<br>3 - Introduction to harmonic analysis - Characterization of stochastic signals and their applications in the analysis of the response of a system - Conditions necessary for the faithful reproduction of signals - Experimental determination of the characteristic parameters of a measurement system |
| 5 | Elements of statistics for measurement data analysis. Measurement uncertainty for industrial quality |
| 30 | Sensors and transducers for mechanical and thermal measurements<br>Motion , displacement and strain measurements<br>- Relative linear and angular displacements: Resistive transducers - Differential transformers - Inductive and capacitive sensors - Synchro systems - Piezoelectric sensors - Electro-optical systems - Digital systems<br>- Linear and angular relative speeds: Indirect measurement - Mechanical and electrical tachometers - Stroboscopes - Electromagnetic transducers<br>- Seismic instruments for measurements of displacements, speeds and absolute accelerations<br>- Strain measurement - Electric resistance strain gages. Electrical resistance. Sensitivity to deformation of the ER: sensitivity to axial and transverse strain, the K calibration factor , experimental determination of K. Linearity, temperature coefficient of the calibration factor. Sensitivity to temperature: apparent thermal strain, compensation by compensating ER and self-compensated ER, The resistance measuring circuit. The Wheatstone deviation bridge - strain gauge equation. The zeroing bridge, the reference bridge method. Bridge supply systems. Types of connection: quarter bridge, half bridge, full bridge. Dynamic characteristics.<br>- Measurements of mechanical forces and torques: primary conversion elements - Measurements of torques on rotating shafts. Strain gauge load cells<br>- Pressure measurements: Primary conversion elements - Diaphragm pressure gauges - Electric vacuum gauges<br>- Temperature measurements: Mechanical thermometers - Thermocouples - Resistance thermometers - Pyrometers. Use of Plank's law. Total irradiation pyrometers. Monochrome lamp pyrometers.<br>- Measurements at room temperature with infrared systems within the infrared field |

| Hrs | Practice |
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| 6 | Elements of statistics and uncertainty evaluation with applications to practical cases of uncertainty evaluation procedures |
| 12 | Calibration procedures of measurement instrumentation for mechanical and thermal measurements |
| 3 | Use of optical and electrical techniques to the experimental characterization of surface strain on specimen and material's samples |