Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Thermomechanical measurements
Course code	47550
Scientific sector	ING-IND/10 + IND-IND/14
Degree	**Master in Industrial Mechanical Engineering**
Semester	II
Year	
Academic year	2020/21
Credits	6
Modular	No

Total lecturing hours	32
Total exercise hours	24
Attendance	
Prerequisites	
Course page	

Specific educational objectives	*The course specifically deals with the fundamental concepts of thermomechanical measuring systems, integrates and complements topics of thermodynamics, heat transfer and mechanics introduced in previous elective courses and supplies some tools useful for the implementation of measuring systems in thermomechanical applications.* *The course consists of a single module of 32 hours of frontal lectures and 24 hours of exercises and is composed by two main parts, the first one mainly dealing with thermal measurements and the second one with mechanical measurements.* *The lectures introduce the fundamentals of measuring systems, by presenting and discussing the general principles of metrology and the definition of an internationally recognized system of units.* *Proper terms and definitions will be introduced, as well as the concepts of accuracy and precision of a measure, the uncertainty associated to a measure and the propagation of the uncertainty along a measuring chain.* *Emphasis will be given in the first part of the course on thermal measurements, presenting the typical temperature sensors used in the industry: thermocouples and resistance temperature detectors. Particular care will be given to the role of calibration, also from a practical perspective. Elements will be finally provided on*

	temperature measurements through optical methods and on pressure and flow measurements. *The second part of the course will be devoted to mechanical measurements, with a peculiar focus on the measurement of the strain of a mechanical component. A description of the working principle of strain gauges will be provided, as well as the use of Wheatstone bridge for the compensation of external effects. Moreover, the course will provide elements of signal processing through filtering and aliasing and of Digital Image Correlation.* *Theoretical topics will be supplemented by practical activities, preferably carried out in the laboratories of the Faculty.* *Exercises proposed during the course will consist in solving practical problems with the aim of giving the students a deeper comprehension and understanding of the topics.*

Lecturers	Dr. Francesco Patuzzi, francesco.patuzzi@unibz.it Dr. Franco Concli, franco.concli@unibz.it Dr. Lorenzo Fraccaroli, lorenzo.fraccaroli@unibz.it
Scientific sector of the lecturer	ING-IND/10 + ING-IND/14
Teaching language	English
Office hours	By appointment
Teaching assistant *(if any)*	-
Office hours	-
List of topics covered	The first part of the course (thermal measurements) will cover the following topics: • Introduction to the principles of measurement systems: measuring chains, accuracy, precision • Review on unit of measurements and conversion • Uncertainty of a measure and uncertainty propagation • Temperature sensors: international scale of temperature, thermocouples, resistance sensors • Calibration of temperature sensors • Elements of optical methods and pressure and flow measurements The second part of the course (mechanical measurements) will cover the following topics: • Introduction to mechanical measures • Strain gauges: working principle of the sensors • Wheatstone bridge: compensation of external effects • Introduction to signal processing: filtering, aliasing • Elements of Digital Image Correlation
Teaching format	*The course consists of lectures in which the topics are*

	presented by the lecturers. There are also classes (exercises) that will give practical examples of the application of the theoretical topics. Course topics will be presented at the blackboard and using electronic slides. Teaching material and additional materials will be provided by the lecturers during the semester.

Learning outcomes	Through the study and the application of the topics presented during the lessons, students should acquire: 1) the knowledge and understanding of the fundamentals principles of thermomechanical measuring systems 2) the ability of applying knowledge and understanding of the theoretical principles to the analysis of thermomechanical measuring systems 3) the ability to make autonomous judgements in the assessment of accuracy and precision of measurement instrumentation and uncertainty of a performed measurement 4) communication skills to correctly and properly present the concepts acquired in the course and to solve simple application problems regarding thermomechanical measurements 5) lifelong learning skills through the possession of the tools for the acquisition of technical information on measuring systems and to update knowledge.
Assessment	**Formative assessment** *In class and laboratory exercises and activities (2,3,4,5)* **Summative assessment** *Examination of the course is carried out by means of an oral exam. The oral examination includes questions to assess the knowledge and understanding of the course topics and questions designed to assess the ability to transfer these skills to case studies and practical applications (1,2,3,4)* *Questions on practical applications also assess the ability of the student to apply the knowledge and understanding of the course topics, the ability to make judgments and finally, the student communication skills (1-5).*
Assessment language	English
Evaluation criteria and criteria for awarding marks	It is relevant for the assessment of the oral exam to: master the specific language (also with respect to teaching language); prove the understanding of the topics

	and learning skills; evaluate and establish relationships between topics; grow specific skills in critical thinking. Regarding the practical applications, it is relevant to clearly describe suitable technical solutions and be able to make critical judgments and apply the theoretical concepts.

Required readings	*Didactic materials will be provided by the professor during the course.* *There is no single textbook that covers the entire course. The course material is collected from various sources that will be announced during the course.* *Some relevant sources are:* - *Ernest O. Doebelin, Measurement systems: application and design, Mcgraw-Hill* - *J. V. Nicholas, D. R. White, Traceable Temperatures: An Introduction to Temperature Measurement and Calibration, Wiley*
Supplementary readings	-