Course guide
230476 - INSTR - Instrumentation

Last modified: 25/05/2023

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics.
710 - EEL - Department of Electronic Engineering.

Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
2. Knowledge of experimental techniques and procedures in the field of physics, engineering and nanotechnology. Ability to design experiments using the scientific method and criteria of efficiency, rationality and cost.
1. Knowledge of experimental data analysis techniques. Knowledge of statistical methods for experimental data treatment. Ability to process, analyze and graphically present experimental data.

Generical:
3. They will have acquired knowledge related to experiments and laboratory instruments and will be competent in a laboratory environment in the ICC field. They will know how to use the instruments and tools of telecommunications and electronic engineering and how to interpret manuals and specifications. They will be able to evaluate the errors and limitations associated with simulation measures and results.
5. ABILITY TO IDENTIFY, FORMULATE, AND SOLVE PHYSICAL ENGINEERING PROBLEMS. Planning and solving physical engineering problems with initiative, making decisions and with creativity. Developing methods of analysis and problem solving in a systematic and creative way.

4. ABILITY TO CONCEIVE, DESIGN, IMPLEMENT, AND OPERATE COMPLEX PHYSICAL ENGINEERING SYSTEMS.
Ability to conceive, design, implement, and operate complex systems in the fields of micro and nano technology, electronics, advanced materials, photonics, biotechnology, and space and nuclear sciences.

Transversal:
6. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.
7. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.

TEACHING METHODOLOGY

This course is divided into four parts: basic instrumentation, sensors, advanced experimental techniques, and virtual instrumentation. The first three parts are mainly descriptive. The content is supplemented with demonstrations and/or visits to see relevant equipment. The virtual instrumentation part is developed in laboratory sessions where students learn the basics of virtual instrumentation using LabVIEW software.

LEARNING OBJECTIVES OF THE SUBJECT

- Knowing the structure, operation and the essential characteristics of a measurement system.
- Understand the basic principle of operation of basic electronic instruments and their main limitations.
- Knowing the physical principle which the operation of the main types of sensors is based.
- Learning the basics of the more common advanced instrumental techniques.
- Knowing the basics of virtual instrumentation by using the Labview software.

STUDY LOAD

Type	Hours	Percentage
Hours large group	39,0	26.00
Self study	93,0	62.00
Hours small group	18,0	12.00

Total learning time: 150 h

CONTENTS

Introduction to instrumentation and data processing

Description:
- General principles of measurement systems.
- Measurements and their uncertainty: precision, accuracy, resolution and sensitivity. Error sources. Evaluation of uncertainty.
- Theory of errors. Propagation.
- Processing and data representation. Fitting and linearization. Calibration.

Full-or-part-time: 16h
Theory classes: 6h
Self study : 10h

Basic electronic instrumentation

Description:
- Equipment for measuring electrical parameters. Analog and digital measurements. Multimeter.
- A/D converter: quantization error and aliasing.
- Equipment for measurements in the time domain: oscilloscope.
- Measuring equipment in the frequency domain: lock-in amplifier and spectrum analyser.
- Impedance measurement. Impedance analyzer.
- Interference and noise. Introduction to passive filters.

Full-or-part-time: 18h
Theory classes: 7h
Self study : 11h

Physical principles of measurements. Sensors

Description:
- Structure and characteristics of a sensor based measurement system. Sensors classification.
- Variable resistance sensors: potentiometric sensors, piezoresistive sensors, resistance temperature detectors (RTD), thermistors, photoresistances, and magnetoresistances.
- Variable reactance sensors: variable and differenctial capacitor, variable reluctance sensors, variable transformers, linear variable differencial transformer (LVDT), electret based sensors.
- Electromagnetic and Hall effect-based sensors. Magnetoelastic sensors.
- Sensors generators: thermoelectrics, piezoelectrics, piroelectrics and fotovoltaics.
- Other types of sensors.

Full-or-part-time: 35h
Theory classes: 13h
Self study : 22h

Introduction to advanced experimental techniques

Description:

- Interaction of radiation with matter: photons (ionizing and non-ionizing), electrons, ions, neutrons
- Analytical techniques. XPS, Auger, XRF, IR, UV-Vis-NIR spectroscopy, Raman. Optical microscopy, SEM, TEM, of atomic forces
- Vacuum technology (vacuum levels, methodology, types of pumps)
- Interference and diffraction. Resolution of optical instruments (telescopes and microscopes). Radiation monochromation (diffraction grids, prisms, interferometers, Johan and Johanson crystals). Diffraction (powder and single crystal). Geometry of diffractometers (Bragg-Brentano, Debye Scherrer, transmission).
- Generation and detection of radiation. Generators : UV, visible and IR light sources, laser, X-rays, electrons (thermionic, Schottky, field emission. Detectors: light, IR, photomultipliers, flashing, ionization chambers, proportional, Geiger, analyzers for charged particles.

Full-or-part-time: 44h
Theory classes: 13h
Guided activities: 4h
Self study : 27h

Virtual instrumentation laboratory using Labview

Description:
It will made six sessions of two-hour lab oriented to use Labview as a tool for virtual instrumentation and remote control of instruments.

Full-or-part-time: 38h
Laboratory classes: 12h
Self study : 26h

Scientific Instrumentation Laboratory

Description:
Two laboratory sessions about
a) Crossbeam station: Scanning Electron Microscope (SEM) and Focus Ion Beam (FIB)
b) Ultra High Vacuum Platform: X-Ray photoelectron Spectroscopy (XPS), Auger Spectroscopy, Atomic Force Microscopy (AFM), Physical Vapour Deposition (PVS) and High Pressure Reaction chamber (HPC).

Visit to the nanomaterials laboratory, ALBA particle accelerator and/or other centers with advanced scientific instrumentation

Full-or-part-time: 19h
Laboratory classes: 6h
Self study : 13h

GRADING SYSTEM

The assessment comprises a final exam (EF), a mid term exam (EP), a group work (TG), and practices (PL).
Final mark = 20% PL + 5% TG + max{30% EP + 45% EF , 75%EF}

BIBLIOGRAPHY

Basic:
- Pallás Areny, R. Instruments electrònics bàsics. Barcelona: Marcombo, 2008. ISBN 84-267-1484-6.
- Pallás Areny, R. Sensores y acondicionadores de señal. 4a ed. Barcelona [etc.]: Marcombo Boixareu, 2003. ISBN 8426713440.
- Pérez García, M.A. Instrumentación electrónica. Madrid: Paraninfo, 2014. ISBN 9788428337021.
- Lyman, C.E. [et al.]. Scanning electron microscopy, X-ray microanalysis, and analytical electron microscopy: a laboratory workbook. New York: Plenum Press, 1990. ISBN 0306435918.
- Manuel Lázaro, A.; Río Fernández, J. del. LabVIEW 7.1: programación gráfica para el control de instrumentación. Madrid: International Thomson Paraninfo, 2005. ISBN 84-973-2391-2.
- Wolf, S.; Smith, R.F.M. Student reference manual for electronic instrumentation laboratories. 2nd ed. Upper Saddle River: Pearson Education, 2004. ISBN 0130421820.

Complementary:
- Williams, D.B.; Carter, C.B. Transmission electron microscopy: a textbook for materials science. 2nd ed. New York ; London: Springer, 2009. ISBN 0387765026.
- Cohen, S.H.; Lightbody, M.L. (eds.). Atomic force microscopy/scanning tunneling microscopy 3 [on line]. New York: Kluwer Academic Publishers, 2002 [Consultation: 29/07/2013]. Available on: http://link.springer.com/book/10.1007/b118422/page/1. ISBN 0306470950.
- Woodruff, D.P. Modern techniques of surface science. 3rd ed. Cambridge: Cambridge University Press, 2016. ISBN 9781107023109.