Course guide
230476 - INSTR - Instrumentation

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: 2022 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-idoma

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.

Generic:
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 INFORMATION 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours small group</td>
<td>18,0</td>
<td>12.00</td>
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<tr>
<td>Hours large group</td>
<td>39,0</td>
<td>26.00</td>
</tr>
<tr>
<td>Self study</td>
<td>93,0</td>
<td>62.00</td>
</tr>
</tbody>
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Total learning time: 150 h

CONTENTS

Introduction to instrumentation and data processing

Description:
- General principles of measurement systems.
- Processing and data representation. Fitting and linearization. Calibration.

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

Basic electronic instrumentation

Description:
- 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 differential capacitor, variable reluctance sensors, variable transformers, linear variable differential transformer (LVDT), electret based sensors.
- Electromagnetic and Hall effect-based sensors. Magnetoelastic sensors.
- Sensors generators: thermoelectrics, piezoelectrics, pyroelectrics and fotovoltaics.
- Other types of sensors.

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

Introduction to advanced experimental techniques

**Description:**
- Vacuum technology, cryogenic and high temperature.
- Light microscopy: optics, fluorescence, and confocal.
- Scanning probe microscopy: STM, AFM, and variants.
- Electron microscopy: SEM, TEM, and complementary techniques.
- Spectroscopies: UV-VIS, FTIR, Raman and XPS / UPS.
- Diffraction: X-ray and neutron.

**Full-or-part-time:** 43h
Theory classes: 13h
Guided activities: 3h
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:**

**Complementary:**