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.
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.
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.
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.

General:
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.
230476 - INSTR - Instrumentation

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

This course is divided into four parts: basic instrumentation, sensors, advanced experimental techniques, and virtual instrumentation.
# 230476 - INSTR - Instrumentation

## Content

<table>
<thead>
<tr>
<th><strong>Introduction to instrumentation and data processing</strong></th>
<th><strong>Learning time:</strong> 16h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Theory classes:</strong> 6h</td>
</tr>
<tr>
<td></td>
<td><strong>Self study:</strong> 10h</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th><strong>Basic electronic instrumentation</strong></th>
<th><strong>Learning time:</strong> 18h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Theory classes:</strong> 7h</td>
</tr>
<tr>
<td></td>
<td><strong>Self study:</strong> 11h</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th><strong>Physical principles of measurements. Sensors</strong></th>
<th><strong>Learning time:</strong> 35h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Theory classes:</strong> 13h</td>
</tr>
<tr>
<td></td>
<td><strong>Self study:</strong> 22h</td>
</tr>
</tbody>
</table>

**Description:**
- Structure and characteristics of a sensor based measurement system. Sensors classification.
- Variable resistance sensors: potentiometric sensors, piezoresistive sensors, resistance temperature detectors (RTD), thermostors, 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. Magnetoelectric sensors.
- Sensors generators: thermoelectrics, piezoelectrics, piroelectrics and fotovoltaics.
- Other types of sensors.
### Introduction to advanced experimental techniques

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>43h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes</td>
<td>13h</td>
</tr>
<tr>
<td>Guided activities</td>
<td>3h</td>
</tr>
<tr>
<td>Self study</td>
<td>27h</td>
</tr>
</tbody>
</table>

**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.

### Virtual instrumentation laboratory using Labview

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>38h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory classes</td>
<td>12h</td>
</tr>
<tr>
<td>Self study</td>
<td>26h</td>
</tr>
</tbody>
</table>

**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.

### Qualification 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:

