Learning objectives of the subject:

The aim of the Electronic Instrumentation part is to understand the principles of measurement theory to specify and use electronic instruments and measuring systems. There will be considered also technical and regulatory standards. Moreover, it will be described and analyzed the different types of sensors for measuring physical quantities related to Information Communication Technologies. The signal conditioning circuits for the sensors will be mounted and test in the laboratory classes. Finally the characteristics of data acquisition systems to register the signals obtained from the sensors will be studied and applied to laboratory classes.
The aim of the Optoelectronics subject is to know optoelectronic devices from a semiconductor point of view. Each device is described in its basic form, and then various improvements and drive circuitry are indicated. First objective is to understand basic semiconductor physics and metal-semiconductor and PN junction performance. Next aims are know the light emission process in LEDs and LASERs devices and their operating parameters, and to understand basic performance of light sensor/receivers as Photoconductors, Solar Cells, Photodiodes and Charge Coupled Devices. Finally other optoelectronics and high frequency devices are also briefly studied and fabrication technology is showed visiting UPC laboratories.

Learning results of the subject:

- Ability to specify, design and use electronic instrumentation and measurement systems.
- Ability to understand the sensors characteristics and its applications
- Ability to design signal conditioning circuits and actuators
- Ability to understand and to explain as semiconductor devices are able to convert electrical current in light and light in electrical current.
- Ability to relate, to quantify, and to characterize the light and the electrical current produced in optoelectronic semiconductor devices.
- Ability to understand materials and geometries used in the construction of optoelectronic devices.
- Ability to analyse and to compare optoelectronic devices from their operating parameters
- Ability to analyse basic operation circuits for optoelectronic devices.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 26h</th>
<th>20.80%</th>
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<tbody>
<tr>
<td>Hours medium group:</td>
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<tr>
<td>Hours small group:</td>
<td>13h</td>
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<tr>
<td>Guided activities:</td>
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<tr>
<td>Self study:</td>
<td>86h</td>
<td>68.80%</td>
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## Content

<table>
<thead>
<tr>
<th>Section</th>
<th>Learning time:</th>
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<tbody>
<tr>
<td>1. Introduction to measurement theory</td>
<td>9h</td>
</tr>
<tr>
<td>2. Basic instruments</td>
<td>11h</td>
</tr>
<tr>
<td>3. Sensor technologies</td>
<td>8h</td>
</tr>
<tr>
<td>4. Signal conditioning circuits</td>
<td>11h</td>
</tr>
</tbody>
</table>

### 1. Introduction to measurement theory

**Description:**
- Instrumentation system topology
- Basic terminology
- Sources of uncertainty and categories
- Uncertainty evaluation and management in measurements

### 2. Basic instruments

**Description:**
- Measurement of electrical magnitudes
- Time and frequency estimators
- Measurement instruments basics
- Programmable instrumentation system

### 3. Sensor technologies

**Description:**
- Modulating sensors
- Generating sensors

### 4. Signal conditioning circuits

**Description:**
- Signal conditioning circuits for modulating sensors (DC & AC)
- Signal conditioning circuits for generating sensors
### 5. Data acquisition systems

**Learning time:** 11h  
- Theory classes: 1h  
- Laboratory classes: 2h  
- Self study: 8h

**Description:**  
- Signal multiplexing  
- A/D D/A conversión

### 6. Smart sensors

**Learning time:** 8h  
- Theory classes: 1h  
- Laboratory classes: 2h  
- Self study: 5h

**Description:**  
- Concept  
- Digital processing algorithms  
- Field buses  
- IEEE 1451 standard

### 7. Semiconductor basics

**Learning time:** 7h  
- Theory classes: 2h  
- Self study: 5h

**Description:**  
1. Semiconductor fundamentals  
2. Semiconductor crystal structures  
3. Energy bands

### 8. Carriers: Recombination, emission, and absorption

**Learning time:** 7h  
- Theory classes: 2h  
- Self study: 5h

**Description:**  
1. Carrier fundamentals  
2. Density of states and carriers distribution  
3. Carrier concentrations  
4. Carrier recombination and generation
## 9. Carrier transport

**Learning time:** 7h
- Theory classes: 2h
- Self study: 5h

**Description:**
1. Carrier electrical currents
2. Drift transport and mobility
3. Diffusion transport
4. Conductivity and resistivity
5. Drift-diffusion model

## 10. Junctions

**Learning time:** 6h
- Theory classes: 1h
- Self study: 5h

**Description:**
1. Equilibrium PN homojunction.
2. Bias PN homojunction
3. Diode I?V equation
4. Transient and small-signal PN homojunction
5. Heterojunctions
6. Metal-semiconductor junctions

## 11. LEDs

**Learning time:** 7h
- Theory classes: 2h
- Self study: 5h

**Description:**
1. Principles
2. Basic Structures
3. Output Spectrum
4. Efficiencies
5. Modulation Effects
6. LED examples
### 12. LASERS

<table>
<thead>
<tr>
<th>Learning time:</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>Self study:</td>
<td>Self study: 5h</td>
</tr>
</tbody>
</table>

**Description:**
1. Principles
2. Heterostructure Laser Diodes
3. Quantum Well Laser Diodes
4. Other Semiconductor Laser Diodes
5. Basic Semiconductor Laser Diode Characteristics

### 13. Photodiodes

<table>
<thead>
<tr>
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<tbody>
<tr>
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</tr>
<tr>
<td>Self study:</td>
<td>Self study: 5h</td>
</tr>
</tbody>
</table>

**Description:**
1. Semiconductor Light Absorption
2. Photoconductive parameters
3. PN Junction photodetection modes
4. PN Junction Photodiode
5. Quantum Efficiency and Responsivity
6. PIN Photodiode
7. APD Avalanche Photodiode
8. Photodiode Circuits

### 14. Solar Cells

<table>
<thead>
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<th>Learning time:</th>
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<tr>
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<td>Theory classes: 2h</td>
</tr>
<tr>
<td>Self study:</td>
<td>Self study: 5h</td>
</tr>
</tbody>
</table>

**Description:**
1. Semiconductor light absorption
2. Solar radiation spectrum
3. Photovoltaic performance
4. Equivalent circuit
5. Photovoltaic parameters
6. Solar cell structures
Planning of activities

<table>
<thead>
<tr>
<th>LABORATORY</th>
<th>Hours: 34h 20m</th>
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<tr>
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<td></td>
<td>Practical classes: 13h</td>
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<tr>
<td></td>
<td>Self study: 13h</td>
</tr>
</tbody>
</table>

**Description:**
- Software for programmable instrumentation.
- Signal conditioning circuits and sensors for weather station.
- Data acquisition and processing
- Small project

EXERCISES

**Description:**
Exercises to strengthen the theoretical knowledge.

SHORT ANSWER TEST (CONTROL)

**Description:**
Mid term control.

EXTENDED ANSWER TEST (FINAL EXAMINATION)

**Description:**
Final examination.

Qualification system

The course is divided into 2 parts: Instrumentation and Optoelectronics. Each part has a weight of 50% in the final score.

The Instrumentation qualification (100 %) takes account:
- 40 % lab work
- 60 % final exam Instrumentation

The Optoelectronics qualification (100 %) takes account:
- 40 % continuous assessment or exam control in the middle of the course
- 60 % continuous assessment or final exam
Bibliography

Basic:


Complementary:

