230463 - FISQ - Quantum Physics

Degree competences to which the subject contributes

**Specific:**
3. Knowledge of structural and functional applications of materials. Knowledge of the physical systems of low dimensionality. Ability to identify systems and/or materials suitable for different engineering applications.
2. Knowledge of the interactions at different matter scales. Ability to analyze functional capabilities of physical systems at various scales.
1. Knowledge of the structure of matter and its properties at molecular and atomic level. Ability to analyze the behavior of materials, electronics and biophysical systems, and the interaction between radiation and matter.

**Generical:**
4. 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.

**Transversal:**
3. 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.
2. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.
1. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

Teaching methodology

The course consists of three theoretical sessions and two practical sessions per week. The theoretical lectures will focus on a detailed presentation of the basic concepts and main results, which will be illustrated with a number of examples. The practical sessions will be devoted to the solution of a variety of exercises and problems.

Learning objectives of the subject

* Demonstrate knowledge of fundamental concepts in quantum physics and will be able to apply this knowledge to discuss quantum phenomena quantitatively in the areas of nuclear, atomic and particle physics.
* Find in quantum physics a wholly new and counterintuitive way of thinking about the microscopic world.
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* Learn how to apply mathematical methods to quantum physics problems, including trigonometric and hyperbolic functions, differentiation and integration techniques, complex algebra and differential equations.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>65h</th>
<th>43.33%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self study:</td>
<td></td>
<td>85h</td>
<td>56.67%</td>
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</table>
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## Content

<table>
<thead>
<tr>
<th>1 Thermal Radiation and Photons</th>
<th>Learning time: 23h</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 6h</td>
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<tr>
<td></td>
<td>Practical classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study: 13h</td>
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</tbody>
</table>

**Description:**
- 1.1 Blackbodies. Wien's and Stephan's Laws.
- 1.2 Planck's Law.
- 1.3 Applications. Radiometry. Cosmic Microwave Background and the Big Bang.
- 1.5 X-Ray Radiation. Bremsstrahlung.
- 1.6 Pair Production and Annihilation.
- 1.7 Photon Absorption and Scattering. Cross Sections.

<table>
<thead>
<tr>
<th>2 Quantization and Early Atomic Models</th>
<th>Learning time: 23h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 6h</td>
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<tr>
<td></td>
<td>Practical classes: 4h</td>
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<tr>
<td></td>
<td>Self study: 13h</td>
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</tbody>
</table>

**Description:**
- 2.1 Wave-Particle Duality and Properties of Matter Waves.
- 2.2 Uncertainty Principle. Einstein's and Born's Interpretations. Wave Functions.
- 2.3 Models of the Atom and Limitations: Thomson, Rutherford, Bohr, Sommerfeld.

<table>
<thead>
<tr>
<th>3 Schrödinger's Theory of Quantum Mechanics</th>
<th>Learning time: 31h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 9h</td>
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<tr>
<td></td>
<td>Practical classes: 5h</td>
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<tr>
<td></td>
<td>Self study: 17h</td>
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</tbody>
</table>

**Description:**
- 3.1 Schrödinger's Equation.
- 3.2 Born's Interpretation of Wave Functions. Expectation Values.
- 3.3 Time-Independent Schrödinger's Equation. Eigenfunctions.
- 3.4 Energy Quantization.
## 4 One-electron Atoms

**Description:**
1. Development and Solution of the Schrödinger Equation.
2. Interpretation of Results Through Probability Densities.
3. Spin and Orbital Angular Momentum.
5. Transition Rates and Selection Rules.

**Learning time:** 30h
- Theory classes: 8h
- Practical classes: 5h
- Self study: 17h

## 5 Properties of Nuclei

**Description:**

**Learning time:** 21h 30m
- Theory classes: 5h
- Practical classes: 3h
- Guided activities: 1h 30m
- Self study: 12h

## 6 Elementary Particles and Quantum Statistics

**Description:**
1. Indistinguishibility and Quantum Statistics. The Exclusion Principle.
2. Distribution Functions.
3. Boltzman, Fermi and Bose Distributions.

**Learning time:** 21h 30m
- Theory classes: 5h
- Practical classes: 3h
- Guided activities: 1h 30m
- Self study: 12h

## Qualification system

There will be a final exam (FE) and a partial exam (PE). Students' participation in practical sessions and work assignment (P) will be also taken into account. The final grade will be obtained as: \( \max\{FE, 0.65 \times FE + 0.20 \times PE + 0.15 \times P\} \).
Bibliography

Basic:


Complementary:


