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230468 - MECQ - Quantum Mechanics

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2019
Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Teaching unit Compulsory)
ECTS credits: 6 Teaching languages: Catalan

Teaching staff

Coordinator: JORDI BORONAT MEDICO

Others: FERNANDO PABLO MAZZANTI CASTRILLEJO

Opening hours

Timetable: In agreement with the student

Degree competences to which the subject contributes

Specific:

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:

2. 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:

1. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.

Teaching methodology

Five teaching hours per week are distributed in three theoretical sessions and two of exercises. Theoretical classes are devoted to the introduction of the main topics and the main relevant results, with some simple exercises to help in the presentation. The practical classes are intended to the solution of a selected set of problems and to the discussion of some particular issues not addressed in the theory sessions.

Learning objectives of the subject

1. To know and understand the grounds of Quantum Mechanics and the mathematical basis on which it works.
2. To be able of solving problems in one and three dimensions using the principles of Quantum Mechanics.
3. To be able of solving dynamic problems, problems with rotational degrees of freedom, and scattering problems, and of applying approximate methods to estimate properties of complex systems.

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Study load

Total learning time: 150h	Hours large group:	65h	43.33%
	Self study:	85h	56.67%

Content

1. Introduction

Learning time: 9h

Theory classes: 3h
Practical classes: 1h
Guided activities: 0h
Self study : 5h

Description:
1.1. Wave-particle duality. De Broglie's hypothesis.
1.2. Wave function. Schrödinger equation.
1.3. Wave packets. Heisenberg uncertainty principle.

2. Mathematical tools of Quantum Mechanics

Learning time: 23h 30m

Theory classes: 6h
Practical classes: 3h
Guided activities: 0h 30m
Self study : 14h

Description:
2.1. Hilbert space and wave functions.
2.2. State space. Dirac notation.
2.3. Operators.
2.4. Representation in discrete bases.
2.5. Representation in continuous bases.

3. Postulates of Quantum Mechanics

Learning time: 25h 30m

Theory classes: 6h
Practical classes: 4h
Guided activities: 0h 30m
Self study : 15h

Description:
3.1. The state of a system.
3.2. Description of physical magnitudes.
3.3. Measurement of physical magnitudes.
3.4. Spectral decomposition.
3.5. Time evolution of states.
3.6. Density matrix. Entanglement.
3.7. Path integrals.

4. One-dimensional problems	Learning time: 17h 15m Theory classes: 4h Practical classes: 3h Guided activities: 0h 15m Self study : 10h

Description:
4.1. Discrete spectrum. Continuous spectrum.
4.2. Free particle.
4.3. Square well potential. Potential barrier. Tunneling. Reflection and transmission coefficients.
4.4. Harmonic oscillator.
4.5. Numerical solution of the Schrödinger equation.

5. Angular momentum. Three-dimensional problems	Learning time: 19h 30m Theory classes: 5h Practical classes: 4h Guided activities: 0h 30m Self study : 10h

Description:
5.1. Orbital angular momentum and spin angular momentum. Pauli matrices.
5.2. General formalism. Angular momentum operator. Eigenfunctions of orbital angular momentum.
5.3. Addition of angular momenta. Clebsh-Gordan coefficients.
5.4. Three-dimensional problems. Separation of variables. Cartesian and spherical coordinates.
5.5. Three-dimensional harmonic oscillator.
5.6. The Hydrogen atom.
5.7. Magnetic fields on central potentials. The normal Zeeman effect.

Qualification system

The score of the course is based on three inputs: a final exam (EF), a partial exam when approximately one half of the chapters are discussed (EP), and the participation of students in exercise sessions (P). The final score derives from the formula: Max{EF,0.65*EF+0.30*EF+0.05*P}

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Bibliography

Basic:

Zettili, N. Quantum mechanics: concepts and applications. 2nd ed. Chichester: Wiley, 2011. ISBN 9780470026793.

Sakurai, J.J.; Napolitano, J. Modern quantum mechanics. 2nd ed. San Francisco: Addison-Wesley, 2011. ISBN 9780805382914.

Auletta, G.; Fortunato, M.; Parisi, G. Quantum mechanics. Cambridge: Cambridge University Press, 2009. ISBN 978-0-521-86963-8.

Cohen-Tannoudji, C.; Diu, B.; Laloë, F. Quantum mechanics. Singapore : Paris: Wiley-VCH ; Hermann, 2005. ISBN 9780471569527.