Course guide
230468 - MECQ - Quantum Mechanics

Last modified: 25/05/2023

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

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-idioma

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
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.
2. Knowledge of the interactions at different matter scales. Ability to analyze functional capabilities of physical systems at various scales.

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.

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

STUDY LOAD

Type	Hours	Percentage
Self study	85,0	56.67
Hours large group	65,0	43.33

Total learning time: 150 h

CONTENTS

1. Introduction

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

Full-or-part-time: 9h
Theory classes: 3h
Practical classes: 1h
Self study : 5h

2. Mathematical tools of Quantum Mechanics

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.

Full-or-part-time: 23h 30m
Theory classes: 6h
Practical classes: 3h
Guided activities: 0h 30m
Self study : 14h

3. Postulates of Quantum Mechanics

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.

Full-or-part-time: 25h 30m
Theory classes: 6h
Practical classes: 4h
Guided activities: 0h 30m
Self study : 15h

4. One-dimensional problems

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.

Full-or-part-time: 17h 15m
Theory classes: 4h
Practical classes: 3h
Guided activities: 0h 15m
Self study : 10h

5. Angular momentum. Three-dimensional problems

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.

Full-or-part-time: 19h 30m
Theory classes: 5h
Practical classes: 4h
Guided activities: 0h 30m
Self study : 10h

GRADING 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}

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., international ed. Essex (England): Pearson, 2014. ISBN 9781292024103.
- 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. 2nd ed. Weinheim, Germany: Wiley-VCH, 2020. ISBN 9783527345533.