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230463 - FISQ - Quantum Physics

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: English

Teaching staff

Coordinator: JORDI JOSE PONT

Others: Gloria Sala Cladellas

Opening hours

Timetable: By appointment

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 conterintuitive way of thinking about the microscopic world.

* Learn how to apply mathematical methods to quantum physics problems, including trigonometric and hyperbolic functions, differentiation and integration techniques, complex algebra and differential equations.

Study load

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

Content

1 Thermal Radiation and Photons	Learning time: 23h Theory classes: 6h Practical classes: 4h Self study : 13h

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.
1.4 Photons. Photoelectric and Compton Effects. Diffraction.
1.5 X-Ray Radiation. Bremsstrahlung.
1.6 Pair Production and Annihilation.
1.7 Photon Absorption and Scattering. Cross Sections.

2 Quantization and Early Atomic Models	Learning time: 23h Theory classes: 6h Practical classes: 4h Self study : 13h

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.
2.4 Quantization of Physical Systems. Atomic Spectra. Wilson-Sommerfeld Rules. Correspondence Principle.

3 Schrödinger's Theory of Quantum Mechanics	Learning time: 31h Theory classes: 9h Practical classes: 5h Self study : 17h

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.
3.5 Solution to the Time-Independent Schrödinger's Equation: Zero and Step Potentials. Barrier Potential and Penetration. Square and Infinite Wells. Simple Harmonic Oscillator Potential.

4 One-electron Atoms	Learning time: 30h Theory classes: 8h Practical classes: 5h Self study : 17h

Description:
4.1 Development and Solution of the Schrödinger Equation.
4.2 Interpretation of Results Through Probability Densities.
4.3 Spin and Orbital Angular Momentum.
4.4 Spin-Orbit Interaction and the Energy Levels of Hydrogen.
4.5 Transition Rates and Selection Rules.

5 Properties of Nuclei	Learning time: 21h 30m Theory classes: 5h Practical classes: 3h Guided activities: 1h 30m Self study : 12h

Description:
5.1 General Characteristics: Masses, Sizes, Abundances, Binding Energy and Excited States.
5.2 Nuclear Models: Liquid Drop, Fermi Gas, Shell Model. Comparison with Experiments.
5.3 Nuclear Decay and Nuclear Reactions. Tunnel Effect. Application to Fusion Reactions Inside the Stars and the Origin of the Elements.

6 Elementary Particles and Quantum Statistics	Learning time: 21h 30m Theory classes: 5h Practical classes: 3h Guided activities: 1h 30m Self study : 12h

Description:
6.1 Indistinguishibility and Quantum Statistics. The Exclusion Principle.
6.2 Distribution Functions.
6.3 Boltzman, Fermi and Bose Distributions.
6.4 The Zoo of Elementary Particles. Fermions and Bosons. Quarks. Electroweak Theory and Quantum Chromodynamics. Grand Unification Theories.

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*FE+0.20*PE+0.15*P}.

Bibliography

Basic:

Eisberg, R.M.; Resnick, R. Quantum physics of atoms, molecules, solids, nuclei, and particles. 2nd revised ed. Wiley, 1985. ISBN 9780471873730.

Griffiths, D.J. Introduction to quantum mechanics. 2nd ed. Upper Saddle River, NJ: Pearson Prentice Hall, 2005. ISBN 0131911759.

Complementary:

Feynman, R.P.; Leighton, R.B.; Sands, M. The Feynman lectures of physics: vol. 3: quantum mechanics. New millennium ed. New York: Basic Books, 2010. ISBN 9780465024179 (V. 3).

Hawking, S.W. The dreams that stuff is made of: the most outstanding papers of quantum physics [on line]. Running Press, 2010 [Consultation: 03/07/2012]. Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10513238>. ISBN 9780762434343.

Pereyra Padilla, P. Fundamentos de física cuántica. Reverté, 2011. ISBN 9788429143744.

Sánchez Gómez, J.L.; Fernández Álvarez-Estrada, R. 100 problemas de física cuántica. Alianza Editorial, 2004. ISBN 9788420686332.