Universitat de les Illes Balears

Syllabus

Subject

Name	11289 - Electronic Nanostructures
Credits	0.88 in-class (22 hours) 2.12 distance (53 hours) 3 total (75 hours).
Group	Group 1, 2S (Campus Extens)
Period	Second semester
Language	English

Lecturers

Lecturers	Office hours for students					
	Starting time	Finishing time	Day	Start date	End date	Office
Antonio Borrás López toni.borras@uib.es	15:00	16:00	Tuesday	13/09/2017	27/07/2018	F.127

Context

Subject

Modern semiconductor technology is based on heterostructures, where the composiiton of a semiconductor can be changed on the scale of nanometre. When the dimensions of a solid are reduced to the size of the characteristic lengths of electrons in the material (de Broglie wavelength, coherence length, localization length, etc.), new physical properties due to quantum effects become apparent. Within this subject, the basic physical concepts of low-dimensional semiconductors and quantum heterojunction will be outlined, considering both transport and optical properties.The student will learn how to apply the knowledge of quantum mechanics, statistical mechanics and solid state physics to analyse practicalphysical properties of severalnanostructures, such as quantum wells, quantum dots, superlattices etc. The course is part of Quantum Systems module included in the Master of Physics (MFMA) UIB.

Lecturer

Antoni Borrás (PhD in Physics, Universitat de les Illes Balears, 2009) is a researcher in the Nuclear, Atomic and Molecular Physics Group. His main research lines are Quantum Information Theory and Environmental Radioactivity, with an special focus on Entanglement Theory.

Requirements

Essential requirements

The course is aimed at students, who already attended theoretical lectures in electrodynamics, classical and quantum mechanics, and a course Introduction to solid state physics.

Recommended

Quantum mechanics. Statistical Physics. A course introduction to solid state physics.

Skills

Specific

* ESQ5 - Understanding of physical properties of low-dimensional semiconductors in external fields.
* CE2 - Students must possess the ability to use and adapt mathematical models to describe physical phenomena of different nature.
* CE3 - To acquire edge-line knowledge in the international scientific research context and demonstrate a full comprehension of theoretical and practical aspects, together with the scientific methodology.

Generic

* CG1 - Sistematic comprehension of a field of knowledge and its related skills and research methods.
* CB7 - Students can apply the broader (or multidisciplinary) acquired knowledge and ability to solve problems in new or unfamiliar environments within contexts related to their field of study.
* CB10 - Students gain the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous.

Basic

* You may consult the basic competencies students will have to achieve by the end of the Master's degree at the following address: http://estudis.uib.cat/master/comp_basiques/

Content

Theme content

Theme 1. Modern status of microelectronic and optoelectronics in semiconductor devices.

Basic properties of low-dimensional semiconductor nanostructures. Square quantum well of finite depth. Parabolic and triangular quantum wells. Quantum wires. Quantum dots. Quantum wells in heterostructures. Superlattices and minibands.

Theme 2. Tunneling transport.

Potential step. T- and S- matrices. Current and conductance. Resonance tunneling. Landauer-Butttiker formalism.

Theme 3. Electric and magnetic fields.

The Schrodinger equation with electric and magnetic fields. The Aharonov-Bohm effect. The Shubnikov- de Haas effect. The quantum Hall effect.

Theme 4. Optical and electro-optical processes in quantum heterostructures.

Optical properties of quantum wells and superlattices. Optical properties of quantum dots and nanocrystals. Quantum confined Stark effect.

Teaching methodology

In-class work activities

Modality	Name	Typ. Grp.	Description	Hours
Theory classes	Lectures	Large group (G)	The main topics of the subject will be explained by the lecturer in these theory classes	18
ECTS tutorials	Tutorials	Small group (P)	Individual or group tutorials	2
Assessment	Project presentations	Large group (G)	Each student will present a report on the main aspects of his work for professor and classmates, which critically analyse the presented results.	2

At the beginning of the semester a schedule of the subject will be made available to students through the UIBdigital platform. The schedule shall at least include the dates when the continuing assessment tests will be conducted and the hand-in dates for the assignments. In addition, the lecturer shall inform students as to whether the subject work plan will be carried out through the schedule or through another way included in the Campus Extens platform.

Distance education work activities

Modality	Name	Description	Hours
Individual self-study	Problems	The students will solve the list of proposed problems.	23
Group or individual self-study	Project	The students will study in detail one of the topics covered in the subject or a paper on the field of quantum entanglement theory. They will present their main conclusions and write a report on it..	30

Specific risks and protective measures

The learning activities of this course do not entail specific health or safety risks for the students and therefore no special protective measures are needed.

Student learning assessment

Project presentations

Modality	Assessment
Technique	Oral tests **(non-retrievable)**
Description	Each student will present a report on the main aspects of his work for professor and classmates, which critically analyse the presented results.
Assessment criteria	Project presentations

Final grade percentage: 20%

Problems

Modality	Individual self-study
Technique	Real or simulated task performance tests **(retrievable)**
Description	The students will solve the list of proposed problems.
Assessment criteria	The students will solve the list of proposed problems.

Final grade percentage: 30%

Project

Modality	Group or individual self-study
Technique	Oral tests **(retrievable)**
Description	The students will study in detail one of the topics covered in the subject or a paper on the field of quantum entanglement theory. They will present their main conclusions and write a report on it..
Assessment criteria	The students will study in detail one of the topics covered in the subject or a paper on the field of quantum entanglement theory. They will present their main conclusions and write a report on it.

Final grade percentage: 50%

Resources, bibliography and additional documentation

Basic bibliography

S. Datta, Electronic transport in Mesoscopic systems, Cambridge U.P., 1995
J.H. Davies, The physics of low-dimensional semiconductors, Cambridge U.P., 1998
P. Harrison, Quantum wells, wires and dots. Theoretical and computational physics of semiconductor nanostructures, Wiiey, 2005

Complementary bibliography

T. Ihn, Semiconductor Nanostructures, Oxford U.P., 2010
D.K. Ferry, S. M. Goodnick, Transport in Nanostructures, Cambridge U.P., 1997
J.L. Birman, R.G. Nazmitdinov, V.I. Yukalov, Effects of symmetry breaking in finite quantum systems. Physics Reports v.526 (2013) 1-91