Universitat de les Illes Balears

Teaching guide

Academic year	2016-17
Subject	11289 - Electronic Nanostructures
Group	Group 1, 2S
Teaching guide	A
Language	English

Subject identification

Subject	11289 - Electronic Nanostructures
Credits	0.88 de presencials (22 hours) 2.12 de no presencials (53 hours) 3 de totals (75 hours).
Group	Group 1, 2S (Campus Extens)
Teaching period	Second semester
Teaching language	English

Professors

Lecturers	Horari d'atenció als alumnes					
	Starting time	Finishing time	Day	Start date	Finish date	Office
Rashid Nazmitdinov - rashid.nazmitdinov@uib.es	You need to book a date with the professor in order to attend a tutorial.					

Contextualisation

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 module, 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 practically physical properties of any nanostructures, such as quantum wells, quantum dots, superlattices etc. The course module is part of Quantum Systems included in the Master of Physics (FAMA) UIB.

Dr.Rashid Nazmitdinov has received his PhD in theoretical nuclear physics in 1979 in Joint Institute for Nuclear Research, Dubna, Russia. In 2002 he joined the research group Atomic, Nuclear and Molecular Physics at Physics Department, UIB. Since 1996 he works actively in the field of mesoscopic physics, including properties of quantum dots, quantum wires, and ballistic transport through nanostructures. In particular, he published a few review articles on various aspects of finite quantum systems such as Bose-Einstein condensates, quantum dots and nuclei.

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.

Date of publication: 16/12/2016

Recommendable

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.
* CE1 - Students must possess the learning skills that enable them to combine specialized knowledge in Astrophysics and Relativity, Geophysical Fluids, Materials Physics, Quantum Systems or Applied Mathematics, with the versatility that provides an open training curriculum.
* 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.
* CB6 - Possess the knowledge and its understanding to provide the basis or opportunity to be original in developing and/or applying ideas, often within a research context.
* 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.

Date of publication: 16/12/2016

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)	Exposition of the course content. Besides the recommended material will be given for autonomous studies.	14
Practical classes	approximate methods	Large group (G)	Discussion of approximate methods used to treat systems in a steady state.	4
ECTS tutorials	individual tutorial	Small group (P)	individual tutorial	2
Assessment		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	Students will conduct several written reports in which they should solve individual assignments.	10
Individual self-study	self-study	Assimilation of the theoretical course. To deepen the obtained knowledge, the student should consult the bibliography given in the course.	33
Group or individual self-study	Presentation	Students develop and present a report, where they critically analyse a scientific work related to the subject.	10

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

Assessment

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	

Final grade percentage: 50%

problems

Modality	Individual self-study
Technique	Papers and projects **(retrievable)**
Description	Students will conduct several written reports in which they should solve individual assignments.
Assessment criteria	Solve the proposed list of problems

Final grade percentage: 30%

Presentation

Modality	Group or individual self-study
Technique	Oral tests **(non-retrievable)**
Description	Students develop and present a report, where they critically analyse a scientific work related to the subject.
Assessment criteria	Present and discuss a relevant paper in the field of semiconductor nanostructures

Final grade percentage: 20%

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