Course Guide
M9-44425 Nanomagnetism and molecular spintronics

COURSE DATA

Data Subject

Code	M9-44425
Name	Nanomagnetism and molecular spintronics
Cycle	Master's degree
ECTS Credits	4.5

Study (s)

Degree	Center	Acad. year	Period
2208 - Master's Degree in Molecular Nanoscience and Nanotechnology	Faculty of Chemistry	1	Second term

Subject-matter

Degree	Subject-matter	Character
2208 - Master's Degree in Molecular Nanoscience and Nanotechnology	9 - Nanomagnetism and molecular spintronics	Obligatory

Coordination

Name	Department
BEDOYA PINTO, AMILCAR	Applied Physics- U. de València

SUMMARY

The general aim of the course is to provide the students with a coherent and modern education of a wide range of fundamental, methodological and technological aspects on nanomagnetism and molecular spintronics.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

Previous knowledge of chemistry, physics or materials science as taught in the degrees indicated in the recommended entry profile to the master's degree is required. Previous knowledge of molecular nanoscience and nanotechnology as taught in the Introduction and Basic Modules is required.

COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

2208 - Master's Degree in Molecular Nanoscience and Nanotechnology

- Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.
- Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.
- Students should demonstrate self-directed learning skills for continued academic growth.
- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- To possess the necessary knowledge and abilities to continue with future studies in the PhD program in Nanoscience and Nanotechnology.
- For students from field of knowledge (e.g. chemistry) to be able to scientifically communicate and interact with colleagues from another field (e.g. physics) in the resolution of problems laid out by the Molecular Nanoscience and Nanotechnology.
- To acquire the basics knowledge in fundamentals, use and applications of microscopic and spectroscopic techniques used in nanotechnology.
- To assess the relationships and differences between the materials macroscopic properties and those of unimolecular systems and nanomaterials.
- To assess the molecules and hybrid materials relevance in electronics, spintronics and molecular nanomagnetism.
- To know the main molecular nanomaterials technological applications and to be able to put them in the Material Science general context.
- To know the main applications of nanoparticles and nanostructured materials ?obtained or functionalised using a molecular approach- in magnetism, molecular electronics and biomedicine.

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

- To acquire the basic knowledge as well as the overall view of the principal research lines of the Nanomagnetism area, including electronic, magnetic and transport properties of low dimensional magnetic systems and nanostructures.
- To know the main experimental technologies (skills) to characterize electronic, magnetic properties and of transport of nanoestructuras. To be able to use experimental tools for measuring magnetic and transport properties of magnetic nanostructures.
- To know and to understand the most relevant magnetic, electronic and transport properties in

magnetic materials at the nanoscale and in nanostructures.

- To know the multiple applications of the magnetic nanostructures as well as the future trends of research within the Nanomagnetism area.

DESCRIPTION OF CONTENTS

1. Molecular nanomagnetism and spintronics.

1. Nanomagnetism basic concepts. Artificial interphases influence, proximity and dimensionality effects. Magnetic textures (magnetic domain, magnetic vortices, skirmions)
2. Magnetic properties and scales. Magnetic inversion process, size effects and dynamic processes. Spintronics (spin valves, MTJ, spin torque effect), orbitronics (Spin Hall effect, Inverse SHE).
3. Characterization experimental techniques of electronic, magnetic and transport properties of nanostructures.
4. Fundamental theoretical models for magnetism and nanoscopic scale related phenomena study.
5. Recent developments and future recent tendencies in Molecular Nanomagnetism (magnetic molecules, single-molecule magnets,).
6. Spintronics based on molecular materials (organic spintronics): Molecular spin-valves fabrication and interphase engineering. Multifunctional devices fabrication.
7. Molecular Nanospintronics (single-molecule devices: quantum computing with magnetic qubits based on molecules).

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	22,50	100
Seminars	7,50	100
Tutorials	6,00	100
Other activities	2,00	100
Preparation of evaluation activities	56,50	0
Preparing lectures	18,00	0
TOTAL	**112,50**	

TEACHING METHODOLOGY

Classes in this subject will be taught, together with the rest of the advanced module, intensively during 3 weeks in May and each year at a different university.

During the **theory classes**, professors will give an overview of the subject under study, emphasising new or particularly complex aspects. The necessary bibliographical sources will be indicated for students to study the subject in depth.

The **practical classes** of this subject will be devoted to the organisation of seminars in which problems related to the theoretical content will be posed and solved. Likewise, practical cases and other topics related to the subject will be discussed with the students.

During these hours of practical activities, as far as possible, visits to laboratories and facilities related to the contents of the theoretical classes will be organised. This includes visits to the controlled atmosphere and clean room device fabrication laboratories and to the magnetic device measurement equipment. In addition, simple practical exercises will be carried out with the main computer programmes used for the theoretical modelling of the properties of spintronic devices.

After the intensive face-to-face classes, the lecturers will ask students a series of **questions** about the contents of the course that the student will have to solve.

Professors will hold **tutorials** with the students to resolve any doubts and questions they may have. These tutorials will take place in person or remotely (email, videoconference, telephone, etc.) depending on whether the student and teacher are from the same or a different university.

Through all these activities, students will acquire the competences described in the corresponding section. The basic competences will be worked on above all during the seminars.

EVALUATION

The acquisition of the competences of the subject will be assessed by means of a written exam based on the questions posed to the students. The mark for this exam will represent 90% of the final mark for the subject.

Student participation during the training activities will represent 10% of the final grade.

In order to pass the course, it will be necessary to have attended 80% of the face-to-face training activities.

REFERENCES

Basic

- Micromachines & Nanotechnology: The Amazing New World of the Ultrasmall, David Darling, Silver Burdett Press, 1995.
  -World Scientific Series in Nanoscience and Nanotechnology: Volume 3. Molecular Cluster Magnets Edited by: Richard Winpenny (The University of Manchester, UK) World Scientific, 2012.
  - J. Stöhr and H.C. Siegmann, Magnetism: From Fundamentals to Nanoscale Dynamics, Springer

Series in solid-state sciences, Springer Berlin Heidelberg New York (2006). ISBN-13 978-3-540-30282-7
- World Scientific Series in Nanoscience & Nanotechnology: Vol. 3. Molecular Cluster Magnets Edited by: R. Winpenny (University of Manchester, UK) World Scientific, 2012. ISBN: 978-981-4464-02-4.

- Focus: Organic Spintronics, Nature Materials 8, No. 9 (September 2009).
- Molecular vs inorganic spintronics: role of molecular materials and single molecules, Julio Camarero & Eugenio Coronado, J. Mater. Chem. Highlight 19, 1678 (2009).