

CÓDE	NAME OF MODULE	TYPE
	TOPICS IN NANOMATERIALS: MAGNETIC NANODEVICES	E

M = mandatory
E = elective

3.3.1. Learning goals of the module.

(List the specific learning goals that the current module should provide to the student; goals can focus on content, skills, or attitudes.)

This module intends to present the state of the art in different aspects of nanomaterials. This year the focus will be put on the magnetic nanodevices.

3.3.2. Methodology: learning activities and credit value of the module (ECTS).

3.3.2.1. Learning activities.

(Time required to teach the module; links to other modules included in the MSc Program and suggested chronological sequence with the latter)

3.3.2.2. ECTS credit value (and time)
1 ECTS credit = 25 hours UPV/EHU

TYPE OF LECTURE ⁽¹⁾	Theory		Practice							Evaluation	
	M ⁽²⁾	S	PA	PL	PO	TA	TAI	PCL	PCC	Periodic Grading	Final Grading

Master's in NANOSCIENCE

Classroom lectures	15	15										3
Personal work ⁽³⁾	25	20										
TOTAL	40	35										3

- (1) M (standard lecture); S (seminar); PA (practical exercises in classroom); PL (practical exercises in laboratory); PO (practical exercises with computers); TA (non-industrial workshops); TAI (industrial workshops); PCL (clinical practice); PCC (field practice); the acronyms are taken from the Spanish wording.
- (2) M = maximum allowed is 60% of the full classroom lectures
- (3) Personal work = time that the student would use to prepare and develop individual and group assignments.

3.3.2.3. Module Program.

(Lectures)

Lecture 1.	Introduction on Magnetism, Magnetic field, Diamagnetic, Paramagnetic, and Ferromagnetic Materials, Soft and hard ferromagnetic materials, Hysteresis, Magnetic domains, Magnetic anisotropy
Lecture 2.	Resume on magnetism of materials with nano and micro-dimensions scales. Introduction to magnetism of microwires and nanowires.
Lecture 3.	Fabrication methods of amorphous materials of special shapes with nano and micro- dimensions: thin films, sandwiches, nanowires, microwires (sputtering, MBE, electro- deposition, Taylor-Ulitovsky method, laser ablation, rapid quenching).
Lecture 4.	Methods of characterization of magnetic properties structure of materials with nano and microdimensions
Lecture 5.	Experimental techniques of magnetic domains observation: Bitter technique, magneto- optical methods, transmission electronic microscope, X-rays, neutrons. Comparison of different techniques of magnetic domains observation.
Lecture 6.	Magnetic domains structures in microwires with positive y negative magnetostriction.
Lecture 7.	Giant Magnetoresistance (GMR).
Lecture 8.	Sensors based on Giant Magnetoresistance (GMR).
Lecture 9.	Giant Magnetoimpedance (GMI).
Lecture 10.	Induced Magnetic Anisotropy and Giant Magnetoimpedance (GMI)
Lecture 11.	Giant Magnetoimpedance in multilayered structures with not uniform conductivity.
Lecture 12.	Sensors based on GMI.

Lecture 13.	Magneto-cryalline, magneto-elastic and induced magnetic anisotropy. Magnetostriction
Lecture 14.	Magnetoelastic Sensors. Micro and Nano Sensors and Actuators.

3.3.2.4. Bibliography.

(Basic and specialized bibliographies, journal references, internet addresses, etc.)

- [1] ζ A.Aharoni, ζ Introduction to the theory of ferromagnetism ζ , Clarendon Press, Oxford, 1996.
- [2] - M.A. Plonus, "Electromagnetismo Aplicado", Ed. Reverté, Barcelona, 1982.
- [3] - J.R. Reitz, F. Milford, R. Christy, "Fundamentos de la teoría Electromagnética", Educación Fondo Educativo Interamericano, México, 1984.
- [4] - S. Velayos, "Temas de Física III: Electromagnetismo", Copygraf, S.L. Madrid, 1976.
- [5] - N.W. Ashcroft, N.D. Mermin, "Solid State Physics", W.B. Saunders Company, Philadelphia, 1976.
- [6] ζ T.H.O ζ Dell, ζ Ferromagnetodynamics. The dynamics of magnetic bubbles, domains and domain walls ζ , Wiley, New York, 1981.
- [7] ζ A.P.Malozemoff, J.C.Slonczewski, ζ Magnetic domain walls in bubble materials ζ , Academic Press, New York, 1979.
- [8] - S. Chikazumi, "Physics of Magnetism", Robert E. Krieger Publishing Company, 1978.
- [9] - D.J. Craik, "Structure and Properties of Magnetic Materials" J.W. Arrowsmith Limited, Bristol, 1971.
- [10] - D. Jiles, "Introduction to Magnetism and Magnetic Materials", Chapman and Hall, 1991.
- [11] - C. D. Mee, E.C. Daniel, "Magnetic Recording", MacGraw Hill Book Company, New York, 1987.
- [12] - A. Hernando, "Nuevos materiales: los vidrios metálicos", Eudema Universidad, 1987.
- [13] ζ L.D.Landau, E.M.Lifshitz, L.P.Pitaevskii, ζ Electrodynamics of Continuous Media, 2nd Edition, Butterworth Heinemann, Exeter, 1995 (460 páginas).
- [14] - S. Velayos, "Introducción al Magnetismo", Servicio de publicaciones de la Facultad de Ciencias, Madrid, 1968.
- [15] ζ K.Handrich, S.Kobe, ζ Amorphe Ferro- und Ferrimagnetika ζ , Akademie-Verlag Berlin 1980 (294 páginas).
- [16] ζ A.Hubert, R.Schäfer, ζ Magnetic domains ζ , Springer-Verlag Berlin Heidelberg, 1998.

3.3.3. Criteria and methods for evaluation and grading

(Analysis of the methodology that will be used to evaluate the learning process of the student)

3.3.4. Learning resources

Students will have access to all bibliographic resources from the UPV/EHU Chemistry Faculty, the Centro de Física de Materiales CSIC-UPV/EHU, and the Donostia International Physics Center DIPC. Online access to the scientific literature from these centers will be also guaranteed.

3.3.5. Language and number of groups attending the module

1	NUMBER OF GROUPS
x	LANGUAGE: ENGLISH

3.3.6. Fields of science and technology to which the module is related

CODE	FIELD
	PHYSICS OF CONDENSED MATTER
	APPLIED PHYSICS

3.3.7. Department in charge of the Program

CODE	DEPARTMENT ⁽¹⁾
	DEPARTMENT OF MATERIALS PHYSICS

3.3.8. Teachers in charge of the module

DNI	Teacher UPV/EHU	Number of credits
X1794268s	Arcady Zhukov	3

DNI	Teacher other institutions	Number of credits