

CÓDE	NAME OF MODULE	TYPE
	FUNDAMENTALS OF NANOSCALE CHARACTERIZATION	M

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.)*

THE AIM OF THIS COURSE IS THAT THE STUDENT ADQUIRES THE BASIC THEORETICAL CONCEPTS THAT ARE BEHIND THE EXPERIMENTAL TECHNIQUES USED TO CHARACTERIZE SOLIDS AND NANOSTRUCTURES. CONCEPTS ON ELASTIC AND INELASTIC SCATTERING PROCESSES WILL BE DEVELOPED PAYING ATTENTION TO THE CHARACTERISTICS OF THE PROBES AND THE THEORETICAL METHODS THAT ARE USED TO DESCRIBE THE INTERACTION WITH THE TARGETS.

### 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)*

THIS MODULE IS SCHEDULED FOR THE SECOND TERM OF THE FIRST COURSE OF THE MASTER. THE IDEA IS THAT THE STUDENT WILL HAVE ADQUIRED THE BASIC KNOWLEDGES NEEDED TO FOLLOW THIS SUBJECT IN THE FUNDAMENTAL SUBJECTS THAT ARE TAUGHT IN THE FIRST TERM OF THE MASTER, SUCH AS "FUNDAMENTALS OF QUANTUM MECHANICS", "CLASSICAL ELECTRODYNAMICS" AND "FUNDAMENTAL OF SOLID STATE PHYSICS". IN ADDITION, THIS MODULE IS COMPLEMENTARY TO THE SUBJECTS THAT ARE ALSO GIVEN IN THIS SECOND TERM OF THE MASTER "EXPÈRIMENTAL TECHNIQUES I" AND "EXPAERIMENTAL TECHNIQUES II"- THESE OTHER SUBJECTS ARE FOCUSED TO THE EXPERIMENTAL PART OF NANOSCALE CHARACTERIZATION.

THE COURSE WILL CONSIST IN 30 HOURS OF LECTURES IN WHICH THE THEORETICAL BODY OF THE SUBJECT WILL BE DEVELOPED.

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

TYPE OF LECTURE <sup>(1)</sup>	Theory		Practice							Evaluation	
	M <sup>(2)</sup>	S	PA	PL	PO	TA	TAI	PCL	PCC	Periodic Grading	Final Grading
Classroom lectures											
Personal work <sup>(3)</sup>											
<b>TOTAL</b>											

- (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	<p>ELASTIC SCATTERING AND DIFFRACTION</p> <p>1.1. ELASTIC SCATTERING OF LIGHT WITH MATTER 1.2. STATIC STRUCTURE FACTOR AND PAIR DISTRIBUTION FUNCTION 1.3. DIFFRACTION IN CRYSTALLINE SOLIDS 1.4. ELASTIC SCATTERING OF ELECTRONS WITH MATTER 1.5. ELASTIC SCATTERING OF NEUTRONS WITH MATTER</p>
Lecture 2	<p>INELASTIC SCATTERING. DYNAMIC STRUCTURE FACTOR AND TIME CORRELATION</p>
Lecture 3	<p>LINEAR RESPONSE THEORY</p> <p>3.1. DENSITY-DENSITY RESPONSE FUNCTION 3.2. NON INTERACTING FERMI GAS 3.3. THE CHARGED FERMI LIQUID AND THE DIELECTRIC FUNCTION 3.4. RANDOM PHASE APPROXIMATION. PLASMONS.</p>
Lecture 4	<p>FUNDAMENTALS OF SPECTROSCOPY</p> <p>4.1. GREEN FUNCTIONS (CLASSICAL, ONE-BODY SCHRÖDINGER EQUATION, SINGLE-PARTICLE FOR MANY-BODY) 4.2. LEHMAN REPRESENTATION. THE SPECTRAL FUNCTION. BROADENING (LINE WIDTH) 4.3. MEASURING THE SPECTRAL FUNCTION WITH SCANNING TUNNELING SPECTROSCOPY. 4.4. TWO-PARTICLE CORRELATION FUNCTIONS (RESPONSE FUNCTIONS)</p>
Lecture 4	<p>DIFFERENT SPECTROSCOPIES</p> <p>5.1. INELASTIC ELECTRONS TUNNELING SPECTROSCOPY (IETS) 5.2. ANGLE RESOLVED PHOTOEMISSION SPECTROSCOPY (ARPES) 5.3. TWO PHOTON PHOTOEMISSION SPECTROSCOPY (2PPE) 5.4. VIBRATIONAL SPECTROSCOPIES: INFRARED (IR), RAMAN AND HREELS 5.5. X-RAY ABSORPTION SPECTROSCOPY (XANES, EXAFS AND NEXAFS)</p>

**3.3.2.4. Bibliography.**

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

"X-RAY DIFFRACTION"  
BY B. E. WARREN  
DOVER PUBLICATIONS, 1990.

"DIFFRACTION PHYSICS"  
BY J. M. COWLEY  
NORTH-HOLLAND PHYSICS PUBLISHERS, 1984.

"TRANSMISSION ELECTRON MICROSCOPY AND DIFFRACTOMETRY OF MATERIALS"  
BY B. FULTZ AND J. M. HOWE  
SPRINGER-VERLAG, 2001.

"DIFFUSE NEUTRON SCATTERING FROM CRYSTALLINE MATERIALS"  
BY V. M. NIELD AND D. A. KEEN  
OXFORD UNIVERSITY PRESS, 2001.

"FUNDAMENTALS OF CRYSTALLOGRAPHY"  
BY C. GIACOVAZZO, H. L. MONACCO, G. ARTIOLI, D. VITERBO, G. FERRARIS, G. GILLI, G. ZANOTTI, AND M. CATTI  
OXFORD UNIVERSITY PRESS, 2002.

"THE THEORY OF QUANTUM LIQUIDS"  
BY PHILIPPE NOZIERES AND DAVID PINES  
PERSEUS BOOKS PUBLISHING, 1999.

"BEYOND THE ONE-ELECTRON MODEL. MANY-BODY EFFECTS IN ATOMS, MOLECULES AND SOLIDS"  
BY CARL-OLOF ALMBLADH AND LARS HEDIN.  
CHAPTER 8 OF HANDBOOK ON SYNCHROTON RADIATION, VOL. 1, EDITED BY E. E. KOCH  
NORTH HOLLAND PUBLISHING COMPANY, 1983.

"SOLID-STATE PHOTOEMISSION AND RELATED METHODS" (THEORY AND EXPERIMENTS)  
EDITED BY WOLFGANG SCHATTKE AND MICHEL A. VAN HOVE.  
WILEY-VCH VERLAG GMBH&CO.KGAA, 2003.

### 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)*

THE PERSONAL WORK OF THE STUDENT DURING THE COURSE WILL BE USED TO EVALUATE THE LEARNING PROCESS. IF IT IS FOUND NECESSARY A WRITTEN EXAM MAY BE USED ALSO TO EVALUATE THE KNOWLEDGE ADQUIRED BY THE STUDENTS.

### 3.3.4. Learning resources

THE STUDENT HAS ACCESS TO THE BIBLIOGRAPHICAL RESOURCES AVAILABLE IN THE UNIVERSITY OF THE BASQUE COUNTRY, "CENTRO DE FÍSICA DE MATERIALES", AND "DONOSTIA INTERNATIONAL PHYSICS CENTER".

### 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 <sup>(1)</sup>
	DEPARTMENT OF MATERIALS PHYSICS

**3.3.8. Teachers in charge of the module**

DNI	Teacher UPV/EHU	Number of credits
00692057x	Andres Arnau Pino	1.5
34089368x	Joseba Iñaki Juaristi Oliden	1.5

DNI	Teacher other institutions	Number of credits