COURSE OUTLINE

(1) GENERAL INFORMATION

SCHOOL	SCHOOL OF APPLIED MATHEMATICAL AND PHYSICAL SCIENCES		
DEPARTMENT	SCHOOL OF APPLIED MATHEMATICAL AND PHYSICAL SCIENCES		
LEVEL OF STUDIES	POSTGRADUATE		
MSc PROGRAM	MICROSYSTEMS AND NANODEVICES		
COURSE CODE	**9965**	**SEMESTER**	**2**
COURSE TITLE	EXPERIMENTAL TECHNIQUES FOR NANOMATERIALS		

INDEPENDENT TEACHING ACTIVITIES *In cases where credits are awarded to discrete parts of the course (e.g., Lectures, Laboratory Exercises, etc.), specify them. If credits are awarded as a whole, specify weekly teaching hours and total credits.*	**WEEKLY TEACHING HOURS**	**ECTS**
Lectures – Exercises	0	6
Laboratory	4	
Assignments	0	
(Additional rows may be added if necessary. Detailed descriptions of teaching organization and methods are provided in section (d).)		

COURSE TYPE *general background, specialized background, specialization, skill development*	SPECIALIZED BACKGROUND (for specialization courses) SPECIALIZATION (for Stream or Specialization Compulsory courses)
PREREQUISITES:	[REQUIRED BACKGROUND KNOWLEDGE]: Solid State Physics.
LANGUAGE OF INSTRUCTION and EXAMINATION:	GREEK
COURSE AVAILABLE TO ERASMUS STUDENTS	YES (offered in English as a reading course).
COURSE WEBSITE (URL)	https://helios.ntua.gr/course/view.php?id=3005

(2) LEARNING OUTCOMES

Learning Outcomes

This section describes the learning outcomes of the course, specifying the knowledge, skills, and competencies at the appropriate level that students will acquire upon successful completion of the course.

Refer to Appendix A:

- *Description of the Level of Learning Outcomes for each cycle of studies according to the European Higher Education Area Qualifications Framework*
- *Descriptive Indicators for Levels 6, 7, & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B.*
- *Concise Guide to Writing Learning Outcomes*

Knowledge:

The aim of the course is to familiarize students with material synthesis and characterization techniques through the following exercises:

- Synthesis using the sol-gel technique and characterization of superabsorbent polymer networks at the nanoscale.
- Stress measurement in steels.
- Measurement of anisotropy changes in steel grains and other magnetic materials.
- Lithography processes and material deposition in a vacuum as thin films or nanoparticles, with characterization through electrical measurements.
- Scanning and Transmission Electron Microscopy (SEM and TEM) for micro- and nanostructured materials and surfaces.
- Dielectric spectroscopy for micro- and nanostructured materials.
- Differential calorimetry for micro- and nanostructured materials.

- Physicochemical characterization of nanomaterials and nanoparticles using dynamic light scattering.
- Physicochemical characterization of organic chromophore compounds and hybrid nanomaterials with steady-state and time-resolved fluorescence spectroscopy.
- Quantum cryptography using the BB84 protocol.

Skills:

Upon successful completion of the course, students will be able to:

- Select the most appropriate technique for synthesizing nanomaterials.
- Choose the most suitable characterization method for the materials under study.
- Combine characterization methods for analyzing the structural properties of materials.
- Understand the interaction of light and electrons with matter.
- Predict the relationship between structure and properties of materials.
- Integrate magnetic and electrical characterization methods for materials.
- Understand the principles of quantum cryptography through experiments.
- Link technology with fundamental physical principles.

General Competencies

Considering the general competencies that graduates are expected to acquire (as stated in the Diploma Supplement), which competencies does this course aim to develop?.

Data search, analysis, and synthesis, utilizing necessary technologies *Adaptability to new situations* *Decision-making* *Independent work (primarily through assignments completed at home)* *Teamwork* *Working in an international environment* *Working in an interdisciplinary environment*	*Generation of new research ideas* *Project design and management* *Respect for diversity and multiculturalism* *Respect for the natural environment* *Exhibiting social, professional, and ethical responsibility and sensitivity to gender issues* *Critical and self-critical thinking* *Promotion of free, creative, and inductive thinking*

Competencies:

Successful completion of the course develops the ability to:

- Organize and present an experimental procedure with scientific precision.
- Work independently to articulate measurement results.
- Analyze data to evaluate material properties.
- Select the most appropriate material characterization method.
- Integrate complementary characterization methods for a comprehensive analysis of materials.
- Adapt to a variety of research topics.
- Link technology with quantum physics and condensed matter physics.

(3) COURSE CONTENT

1. **Synthesis and Characterization of Superabsorbent Polymer Networks at the Nanoscale using the Sol-Gel Technique.** *Objective:* To synthesize nanostructures using the sol-gel technique, which involves transitioning a colloidal liquid form (sol) into a solid form (gel) for potential use based on the specific functional properties of these nanostructures.
2. **Stress Measurement in Steels and Anisotropy Changes in Steel Grains and Other Magnetic Materials.** *Objective:* To measure changes in anisotropy within steel grains and other magnetic materials using the Barkhausen effect as part of Non-Destructive Testing (NDT) methods. The generated signal is influenced by the material's structure and any present defects or impurities.

3. **Lithography and Material Deposition Processes in Vacuum for Thin Films and Nanoparticles with Electrical Characterization.** *Objective:* To familiarize students with thin film deposition techniques, particularly sputtering, and to form patterned films using optical lithography and appropriate masks.
4. **Scanning and Transmission Electron Microscopy (SEM - TEM) for Micro- and Nanostructured Materials and Surfaces.** *Objective:* To introduce scanning and transmission electron microscopy, explain their operating principles, and apply basic techniques for extracting material information using these microscopes.
5. **Dielectric Spectroscopy on Micro- and Nanostructured Materials.** *Objective:* To introduce dielectric spectroscopy methods and experimental setups, with applications demonstrated for characterizing and studying nanomaterials and traditional technological materials.
6. **Differential Scanning Calorimetry (DSC) in Micro- and Nanostructured Materials.** *Objective:* To study the physical properties of materials as a function of temperature, with examples including nanomaterials and traditional technological materials.
7. **Physicochemical Characterization of Nanomaterials and Nanoparticles via Dynamic Light Scattering (DLS).** *Objective:* To understand the technique of dynamic light scattering for determining the structural characteristics of nanomaterials dispersed in liquid solutions as a function of their concentration and temperature.
8. **Physicochemical Characterization of Organic Chromophores and Hybrid Nanomaterials using Fluorescence Spectroscopy and ultra-violet-visible (UV-Vis) absorption Spectroscopy.** *Objective:* To gain theoretical and practical knowledge of steady-state and time-resolved fluorescence spectroscopy and UV-Vis absorption spectroscopy for organic chromophore molecules at varying concentrations in solution.
9. **Quantum Cryptography using the BB84 Protocol.** *Objective:* To understand and implement the basic unit of quantum information (qubit) through light polarization and apply the BB84 quantum cryptography protocol for secure key exchange between two parties.

(4) TEACHING AND LEARNING METHODS - ASSESSMENT

TEACHING METHOD *In person, Distance Learning etc.*	In person
USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT) *Use of Information and Communication Technologies (ICT) in Lecturing, Laboratory Training, Communication with Students*	Use of ICT in Communication with Students (Course Schedule, Lecture Notes, Assignment distribution by the lecturer and submission by students through Helios platform.)
ORGANIZATION OF TEACHING *A detailed description of the teaching methods and approaches used in the course, which may include:* *Lectures, Seminars, Laboratory Exercises, Fieldwork, Study and Analysis of Bibliography, Tutorials, Internships, Clinical Exercises, Art Workshops, Interactive Teaching, Educational Visits, Project Development, Report Writing/Assignments, Artistic Creation.* *The student's study hours for each learning activity, as well as hours of independent study, are outlined in accordance with ECTS principles.*	see table below
STUDENT ASSESSMENT *Description of the Assessment Process*	Language of Assessment: Greek (for Erasmus students: English)

Activity	*Semester Workload*
Lectures	
Study	4x9=36 hours
Home Assignments/Exercises	
Laboratory	4x9=36 hours
Completion/Presentation of Project	4x9=36 hours
Educational Visits	0
Examinations	
Total Course Load	118 [ECTS×13×2,2]

Language of Assessment, Assessment Methods, Formative / Summative Assessment Methods, Multiple-choice tests, Short-answer questions, Essay-style questions, Problem-solving exercises, Written assignments, Reports, Oral examinations, Public presentations, Laboratory work, Clinical patient examinations, Artistic interpretations, Other methods, as appropriate *The assessment criteria are clearly defined and provided to students, ensuring transparency in the evaluation process. These criteria are accessible through the course's online platform where students can review them at any time.*	Written Examination (problem-solving): 0% of final grade Laboratory Work: 50% of final grade Project Completion/Presentation: 50% of final grade These assessment criteria will be explicitly stated on the Helios platform.

(5) RECOMMENDED BIBLIOGRAPHY

Recommended Bibliography ***Laboratory guides for all exercises.***