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 MATERIALS SCIENCE AND TECHNOLOGY PHYSICS AND TECHNOLOGICAL APPLICATIONS		
COURSE CODE	**9967**	**SEMESTER**	**2**
COURSE TITLE	MAGNETISM AND MAGNETIC MATERIALS		

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	2	6
Laboratory	1	
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
PREREQUISITES:	[REQUIRED BACKGROUND KNOWLEDGE]: Quantum Theory of Matter, Statistics, Electromagnetism, Differential Equations
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=3020

(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:

By attending the course, students will acquire knowledge related to:

- The origins of magnetism and the fundamental properties of magnetic materials, with emphasis in ferromagnetic materials
- Technologies for the fabrication and characterization of magnetic materials
- Design principles and applications of magnetic materials in sensors, actuators, and systems

Skills:

Upon completing the course, students are expected to be able to:

- Apply methods for calculating the fundamental properties and structure of magnetic

materials.

- Understand the operating principles underlying the use of magnetic materials insensors, actuators, and systems.
- Employ techniques to tailor the properties of magnetic materials given a specific application

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:

- Search for, analyze, and synthesize data and information, utilizing appropriate technologies.
- Work collaboratively through group assignments.
- Select appropriate physical parameters/variables that define a physical/scientific/technological problem.
- Formulate physical/scientific/technological problems in mathematical terms.
- Integrate knowledge and skills to: (a) analyze complex problems, or (b) choose suitable tools, methods, and approaches to simulate and understand magnetic phenomena.

(3) COURSE CONTENT

Theory

1. **Introduction to magnetism (origins of magnetism, magnetostatics, diamagnetism, paramagnetism, ferromagnetism)**
2. **The ferromagnetic structure (quantum magnetic moments, magnetic order, short - & long – range magnetic interaction thermodynamic approach)**
3. **The magnetization process (magnetic domain wall movement and magnetic domain rotation, parametric dependence of magnetization, families of ferromagnetic materials)**
4. **Magnetic phenomena (inductive effects, magnetostriction, magneto-transport effects, magneto-optic effects, other magnetic effects)**
5. **Magnetic characterization technologies (magnetization loop, magnetostriction loop, magneto-resistance loop, magneto-optic dependence, parametric dependence)**
6. **Metallic magnetic alloys (Fe, Co, Ni, classic magnetic compounds, tailoring of magnetic properties)**
7. **Magnetic oxides (spinnels, ferrites, orthoferrites, garnets, magnetic semiconductors)**
8. **Special families of magnetic materials (2-d and 1-d magnetic materials, rapidly quenched materials, magnetic powders)**
9. **Superconductivity and superconducting materials (quantum theory of superconductivity, superconducting materials, superconducting effects and devices)**
10. **Sensors and transducers (mechanical sensors, magnetometers, other sensors)**
11. **Read & write information (recording media, recording technology, NVMRAMs)**
12. **Electromechanical magnetic systems (macro & micro systems, applications)**

Lab courses:

1. **Magnetization loop, magnetostriction loop, magneto-resistance loop**
2. **Linear variable differential transformer**
3. **Fluxgate magnetometers (classic fluxgates, orthogonal fluxgates, rotating field fluxgates)**
4. **Magnetoimpedance, anisotropic magnetoresistance, giant magnetoresistance**
5. **Magnetostrictive delay lines, sensors applications**
6. **Barkhausen noise**
7. **Steel health monitoring by stress tensor distribution monitoring in steels**
8. **Read and write information, non-volatile RAMs**

Permanent magnetic and superconductors

(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*	Course Notes, Assignments for Home Study **(**Assignments are provided by the lecturer, and students are required to submit completed work)
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.*	

Activity	***Semester Workload***
Lectures	13x3=39 hours
Study	13x3=39 hours
Home Assignments/Exercises	13x3=39 hours
Laboratory	13x1=13 hours
Completion/Presentation of Project	13x2=26 hours
Educational Visits	0
Examinations	3 hours
Total Course Load	146

STUDENT ASSESSMENT *Description of the Assessment Process* *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.*	Language of Assessment: Greek (for Erasmus students: English) **Homework (Problem Solving):** 10% of the final grade **Laboratory Reports:** 30% of the final grade **Written Examination or Completion/Presentation of an Alternative Project:** 60% of the final grade

(5) RECOMMENDED BIBLIOGRAPHY

Review Bibliography

- ***Sushin Chikazumi, Physics of Ferromagnetism, ISBN-13: 978-0882756622***
- ***Amikam Aharoni, Introduction to the Theory of Ferromagnetism (International Series of Monographs on Physics)***
- ***J. M. D. Coey, Magnetism and Magnetic Materials, ISBN-13: 978-0521816144***