COURSE OUTLINE

(1) GENERAL INFORMATION

<table>
<tr><td>SCHOOL</td><td colspan="3">SCHOOL OF APPLIED MATHEMATICAL AND PHYSICAL SCIENCES</td></tr>
<tr><td>DEPARTMENT</td><td colspan="3">SCHOOL OF APPLIED MATHEMATICAL AND PHYSICAL SCIENCES</td></tr>
<tr><td>LEVEL OF STUDIES</td><td colspan="3">POSTGRADUATE</td></tr>
<tr><td>MSc PROGRAM</td><td colspan="3">MICROSYSTEMS AND NANODEVICES</td></tr>
<tr><td>COURSE CODE</td><td>9966</td><td>SEMESTER</td><td>2</td></tr>
<tr><td>COURSE TITLE</td><td colspan="3">ORGANIC NANOMATERIALS</td></tr>
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<tr><td>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.</td><td>WEEKLY TEACHING HOURS</td><td>ECTS</td></tr>
<tr><td>Lectures – Exercises</td><td>3</td><td>6</td></tr>
<tr><td>Laboratory</td><td>0</td><td></td></tr>
<tr><td>Assignments</td><td>0</td><td></td></tr>
<tr><td>(Additional rows may be added if necessary. Detailed descriptions of teaching organization and methods are provided in section (d).)</td><td></td><td></td></tr>
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<table>
<tr><td>COURSE TYPE
general background, specialized background, specialization, skill development</td><td>SPECIALIZATION (Elective Course)</td></tr>
<tr><td>PREREQUISITES:</td><td>[REQUIRED BACKGROUND KNOWLEDGE]:
Solid State Physics, Quantum Mechanics, Electromagnetism, Organic Chemistry</td></tr>
<tr><td>LANGUAGE OF INSTRUCTION and EXAMINATION:</td><td>GREEK</td></tr>
<tr><td>COURSE AVAILABLE TO ERASMUS STUDENTS</td><td>YES (offered in English as a reading course).</td></tr>
<tr><td>COURSE WEBSITE (URL)</td><td>https://helios.ntua.gr/course/view.php?id=3019</td></tr>
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(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:

In the first part of the course, students are introduced to Soft Matter, followed by the fundamental principles of polymer and macromolecular physics. They explore copolymers, phase compatibility, and the self-organization of macromolecules that are composed of monomers with different properties. The course then covers nanotechnology, focusing on the physics and characteristics of nanoparticles. It delves into organic nanoparticles and polymer nanocomposites with various inclusions within polymeric matrices. Through studying four families of polymer nanocomposites, students learn how nanotechnology influences diverse properties of polymer matrices, resulting in new materials with applications in fields like electronics, food packaging, and tissue engineering. In the second part, the course establishes a foundation for understanding conductivity in conjugated polymers and their applications in electronic devices. Beginning with a review of chemical bonding in organic chemistry, the Huckel model is developed for conjugated polymers. Students learn to calculate extended electronic states in carbon chains and systems with heteroatoms. Key conductivity mechanisms in conjugated polymers are analyzed using a general mesoscale model, equipping students to interpret experimental data and identify primary conductivity types. The final section explores fundamental organic microelectronic devices, such as photodiodes, photovoltaics, and transistors, along with an overview of molecular electronics and applications in sensors.

Skills:

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

- Understand the factors that determine the structure and morphology of polymer systems.
- Explain the novel properties of nanoparticles compared to bulk materials.
- Propose appropriate nanoparticle modifications to achieve specific properties.
- Predict and evaluate the properties of polymer nanocomposites based on the characteristics of the inclusions.
- Recommend suitable organic nanomaterials or nanostructured materials for specific applications.
- Appreciate the interdisciplinary nature of the field of organic nanomaterials and their applications.
- Assess whether an organic material can be conductive.
- Identify conductivity mechanisms by analyzing the electrical characteristics of an organic device.
- Understand parameters related to the optimal performance of organic LEDs and photodiodes.

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 cultivates the ability to:

- Work independently (through problem-solving exercises).
- Identify variations in nanoparticles and select the appropriate morphological structure for nanocomposites to meet specified requirements.
- Design new organic nanomaterials by combining knowledge of material properties, processing techniques, and the final morphology of the nanomaterial.
- Search for, analyze, and synthesize data and information (using necessary technologies) and adapt them to specific technological challenges, applying reasonable and necessary approaches for processing and production.
- Integrate knowledge and skills: (a) to analyze a complex problem, or (b) to select suitable tools, methods, and approaches to synthesize data for designing new materials and devices.

(3) COURSE CONTENT

- **Physical properties of macromolecules – Architecture of polymers.**
- **Nanostructured polymers: copolymers, polymer blends, interpenetrating polymer networks, star polymers, hyperbranched polymers.**
- **Nanotechnology and unique properties of nanomaterials – Selected nanoparticles**
- **Preparation, processing and properties of polymer nanocomposites.**
- **Selected applications of polymer nanocomposites: structural materials, packaging materials, biomedical applications.**
- **Electrical properties of organic materials, conducting nanocomposite materials, percolation phenomena.**
- **Applications of conducting organic materials: molecular electronics, photovoltaics, electromagnetic shielding.**

(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, Quizzes, and Homework Problem Sets **(**Quizzes and problem sets assigned by the lecturer, with submission by students and in-class discussion of solutions.)
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)

Activity	*Semester Workload*
Lectures	13x3=39 hours
Study	13x4=52 hours
Home Assignments/Exercises	12x5 = 60 hours
Laboratory	
Completion/Presentation of Project	
Educational Visits	0
Examinations	3 hours
Total Course Load	151 hours

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 Assignments: 20% of the final grade Written Examination (problem-solving): 80% of the final grade Laboratory Work: 0% of the final grade Project Completion/Presentation: 0% of the final grade The assessment criteria are explicitly outlined and accessible to students on the Helios platform.

(5) RECOMMENDED BIBLIOGRAPHY

Recommended Bibliography

Books:

- *U. W. Gedde, Polymer Physics, Chapman & Hall, 1995*
- *N. Hadjichristidis, S. Pispas, G. Floudas, Block Copolymers: Synthetic Strategies, Physical Properties, and Applications, John Wiley & Sons, 2003*
- *R. A. Pethrick, Polymer Structure Characterization: From Nano to Macro Organization, Royal Society of Chemistry, UK, 2007*
- *Ch. P. Poole, Jr., F. J. Owens, Introduction to Nanotechnology, John Wiley & Sons, 2003*
- *Waser, Nanoelectronics and Information Technology, Wiley, 2003, Chapters 38 and 40*
- *Lecture Notes*

Review Articles in Scientific Journals:

- *Guido Kickelbick, Concepts for the incorporation of inorganic building blocks into organic polymers on a nanoscale, Prog. Polym. Sci. 28, 83–114, 2003*
- *G. G. Vogiatzis, D. N. Theodorou, Multiscale Molecular Simulations of Polymer-Matrix Nanocomposites or What Molecular Simulations Have Taught us About the Fascinating Nanoworld, Arch Computat Methods Eng, 2017*
- *J. Jancar et al., Current issues in research on structure-property relationships in polymer nanocomposites, Polymer 51, 3321–3343, 2010*
- *A. MacDiarmid, Synthetic Metals: A novel role for organic polymers, Current Applied Physics 269, 2001*
- *A. Brown et al., Field effect transistors made from solution processed organic semiconductors, Synthetic Metals, 1997*
- *MST-news, Special Issue, August 2003, Polymer Electronics*
- *A. Pron and P. Rannou, Processible conjugated polymers, Prog. Polym. Sci., 27, 135, 2002*