COURSE OUTLINE

(1) GENERAL INFORMATION

SCHOOL	SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING		
DEPARTMENT	SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING		
LEVEL OF STUDIES	POSTGRADUATE		
MSc PROGRAM	MICROSYSTEMS AND NANODEVICES		
COURSE CODE	**9956**	**SEMESTER**	**2**
COURSE TITLE	BIONANOTECHNOLOGY FOR SENSING AND OPTICAL IMAGING		

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	3	6
Laboratory		
Assignments		
(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*	SPECIALIZATION
PREREQUISITES:	[REQUIRED BACKGROUND KNOWLEDGE]: Wave Optics, Electromagnetism
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=3012#section-0

(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:

This course focuses on the contemporary field of Nanobiophotonics, which integrates concepts from the Life Sciences, Nanotechnology, and Photonics. The curriculum aims to foster an understanding of the multidisciplinary nature of Nanobiophotonics. Starting with the fundamental principles of light interactions with biological macromolecules, cells, and tissues, it introduces students to the following areas: Molecular Bioimaging in 2D and 3D, Diagnostic and Therapeutic Techniques Based on Nanotechnology, Biomarker Measurements with Multiplexing, and Nanobiosensors.

Skills:

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

- **Understand nanoscale studies** of light interactions with biosystems and their modeling.
- **Generalize and apply prior knowledge** to diagnostic and therapeutic techniques based on

nanotechnology.

- **Comprehend imaging methodologies and techniques** for cells, biological macromolecules, and biomaterials.
- **Develop critical thinking** by analyzing and solving various case studies related to nanobiophotonic issues and challenges.
- **Extract measurable outcomes** that can be applied in real-world conditions.
- **Combine their technical knowledge background with the field of health sciences.**
- **Collaborate effectively with peers** to achieve a common learning objective, such as completing a group project.

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:

Upon successful completion of the course, students will develop the following competencies:

- **Independent and Collaborative Work**: Ability to work independently (through individual lab work) and collaboratively (through group projects).
- **Effective Team Collaboration**: Skills in productive teamwork to complete a group deliverable and achieve a shared learning goal.
- **Critical Thinking and Cross-Disciplinary Knowledge Integration**: Capacity to develop critical thinking and combine knowledge from various fields through analysis, synthesis, and problem-solving in case studies related to nanobiophotonics.
- **Data Analysis and Synthesis**: Proficiency in searching for, analyzing, and synthesizing data and information using relevant technologies and software tools.
- **Integration of Technological Knowledge with Health Sciences**: Ability to connect their technological background and expertise with health sciences, fostering an interdisciplinary approach.

(3) COURSE CONTENT

Course Units

Unit A: Fundamental Principles of Light Interactions with Biological Macromolecules, Cells, and Tissues

- Overview of light absorption and fluorescence in biological tissues.
- Light propagation through tissues.
- Optical biopsy using absorption, scattering, and fluorescence techniques.

Unit B: Nanobioimaging

- Fluorescence Imaging Microscopy: Techniques and applications.
- Fluorescent Chromophores: Classical dyes, quantum dots, and fluorescent proteins.
- Spatiotemporal imaging of cells and cellular processes and quantification of the observed phenomena.
- Confocal laser scanning microscopy.
- Atomic force microscopy (AFM) for imaging biological macromolecules and biomaterials.
- Optical biosensors and their applications in biological sensing.

Unit C: Applications of Nanobiophotonics in Medicine

- Photodynamic therapy and nanotechnology.
- Use of nanoparticles in medicine for diagnostic and therapeutic purposes.
- Nanoparticle toxicity and its implications.

Unit D: Microarray Technology in Genomics and Proteomics

- Microarray technology for high-throughput analysis in genomics and proteomics.
- Multiplexing systems for simultaneous detection of numerous biomarkers.
- Practical applications of microarrays in biomedical research and diagnostics.

(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 Teaching and Communication with Students (Support of the Learning Process through the Helios Electronic 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.*	

Activity	***Semester Workload***
Lectures	13x3=39 hours
Study	13x3=39 hours
Home Assignments/Exercises	5x3=15 hours
Laboratory	5x3=15 hours
Completion/Presentation of Project	10x5=50 hours
Educational Visits	
Examinations	
Total Course Load	158 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) **Home Assignments:** 5% of the final grade **Written Examination (problem-solving):** 60% of the final grade **Laboratory**: 5% of the final grade **Completion/Presentation of Project:** 30% of the final grade

(5) RECOMMENDED BIBLIOGRAPHY

Recommended Bibliography

- Διδώ Γιόβα, Εισαγωγή στη Νανοβιοφυσική και Οπτική Απεικόνιση, Αθήνα: Συμμετρία. 2011
- Paras Prasad, Introduction to Biophotonics, New Jersey: John Wiley & Son Inc, 2006.
- Tuan Vo-DINH, Biomedical Photonics Handbook: Volume I: Fundamentals, Devices, and Techniques, CRC Press, 2019.
- Tuan Vo-DINH, Biomedical Photonics Handbook: Volume II: Biomedical Diagnostics, CRC Press, 2019.
- Tuan Vo-DINH, Biomedical Photonics Handbook: Volume III: Therapeutics and Advanced Biophotonics, CRC Press, 2019.
- Stephen Paddock, Confocal Microscopy: Methods and Protocols, Humana Press, 2014.

- Bert Voigtländer, Atomic Force Microscopy, Part of the book series: NanoScience and Technology, Springer 2019.
- Caroline Boudoux, Fundamentals of Biomedical Optics: From light interactions with cells to complex imaging systems, Blurb, 2023