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	**9959**	**SEMESTER**	**2**
COURSE TITLE	QUANTUM COMPUTERS		

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	2.5	6
Laboratory	0.5	
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*	SPECIALIZATION
PREREQUISITES:	[REQUIRED BACKGROUND KNOWLEDGE]: Solid State Physics and Chemistry. Analytical Material Characterization Techniques. Fundamental Quantum Mechanics. Undergraduate-Level Physics, Chemistry, and Mathematics, Programming Skills: Proficiency in at least one programming language, Basic Electronics and Electrical Engineering. It is also recommended that students have previously taken a course in micro- and nanosystem fabrication processes
LANGUAGE OF INSTRUCTION and EXAMINATION:	GREEK
COURSE AVAILABLE TO ERASMUS STUDENTS	YES (offered in English as a reading course).
COURSE WEBSITE (URL)	

(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:

Skills:

By the end of the course, students have become familiar with quantum circuits and their use in quantum computing. They have been introduced to fundamental concepts of Open Quantum Systems Physics and have developed proficiency with the density operator formalism, essential for quantum computation. Additionally, they understand the necessity of and methods for error correction and mitigation. Students also gain coherent introductory knowledge of key physical methods and techniques for implementing quantum computing, as well as the emerging new quantum technologies. With this foundation, they are equipped to follow advancements in the fields of quantum technology and quantum computing.

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 fosters the ability to:

- Work independently (and, secondarily, in teams through assigned group projects).
- Evaluate, analyze, and synthesize data and information in a rapidly evolving field at the frontier of what is possible, intersecting science and practical applications. This includes not only quantum computing but also applications in quantum sensors.
- Achieve a systematic, integrative understanding of complex phenomena and processes involved in emerging quantum technologies, where quantum coherence is critical, as well as in quantum computing algorithms..

(3) COURSE CONTENT

Introduction to Quantum Mechanics:
Hilbert Space, Quantum Entanglement, Density Matrix, Operators, Open Quantum Systems, Unitary and Stochastic Dynamics.

Quantum Information:
Quantum Bits and Quantum Gates, Teleportation, No Cloning, Quantum Cryptography, Quantum Error Correction.

Quantum Computation:
Quantum Parallelism, Algorithms of Deutsch and Deutsch–Jozsa, Quantum Fourier Transform, Shor’s Factorization, Grover’s Search, Graph States and Codes, Fault-Tolerant Computation.

Physical Realizations:
NMR, Ions in Traps, Optical Lattices, Quantum Dots, Superconducting Qubits, Topological Quantum Computing.

(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). Presentations
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 workload table below)
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) Proofs of key mathematical relationships involved in understanding quantum technology and quantum information methods, assigned as homework throughout the course. Final Individual Project Alternative Project: group-based

Activity	***Semester Workload***
Lectures	13x3=39 hours
Study	13x4=52 hours
Home Assignments/Exercises	13x4=52 hours
Laboratory	0
Completion/Presentation of Project	32 hours
Educational Visits	0
Examinations	
Total Course Load	[ECTS×13×2,2] 174]

(5) RECOMMENDED BIBLIOGRAPHY

Representative Textbook References:

J. Preskill, *Quantum Computation*, Notes, Caltech, http://www.theory.caltech.edu/people/preskill/ph229/

M.A. Nielsen and I.L. Chuang, *Quantum Computation and Quantum Information*, Cambridge University Press, 2000.