COURSE OUTLINE

(1) GENERAL INFORMATION

SCHOOL	APPLIED MATHEMATICAL AND PHYSICAL SCIENCES		
DEPARTMENT	APPLIED MATHEMATICAL AND PHYSICAL SCIENCES		
LEVEL OF STUDIES	POSTGRADUATE		
MSc PROGRAM	MICROSYSTEMS AND NANODEVICES		
COURSE CODE	**9951**	**SEMESTER**	**1**
COURSE TITLE	QUANTUM THEORY OF MATTER		

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	4	7.5
Laboratory	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*	GENERAL BACKGROUND (for Core Courses)
PREREQUISITES:	[REQUIRED BACKGROUND KNOWLEDGE]: Quantum Mechanics, Statistical Physics, Condensed Matter Physics, Electromagnetism
LANGUAGE OF INSTRUCTION and EXAMINATION:	GREEK OR ENGLISH
COURSE AVAILABLE TO ERASMUS STUDENTS	YES (offered in English).
COURSE WEBSITE (URL)	https://helios.ntua.gr/course/view.php?id=3001

(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:

1) **Quantum Mechanics**: Fundamental Concepts and Mathematical Tools of Quantum Mechanics, Harmonic Oscillator, Angular Momentum, Hydrogen Atom, Spin, Perturbation Theory.

2) **Solid State Physics**: Elements of Theory of Chemical Bonding, Crystal Structures, Direct and Reciprocal Space, Bloch Theorem, Symmetries, Energy Bands and Density of States, Linear Combination of Atomic Orbitals (LCAO) method for band calculations.

Skills:

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

- Understand the fundamental concepts and mathematical tools of Quantum Mechanics.
- Apply fundamental concepts and mathematical tools of Quantum Mechanics to solve representative problems, such as one-dimensional potential wells, the quantum harmonic oscillator, quantum angular momentum, the hydrogen atom, etc.
- Understand the basic concepts and mathematical tools of Solid-State Physics.
- Apply fundamental concepts and mathematical tools of Solid State Physics to solve representative problems, such as determining the structural properties of typical crystals, the formation of chemical bonds, identifying the reciprocal lattice and Brillouin zones, determining electronic properties of crystals (energy bands, density of states), and more.

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 ability to:

- Work Independently (and secondarily in teams, encouraged by collaborative problem-solving exercises).
- Select Appropriate Physical Parameters/Variables that define a physical/scientific problem.
- Formulate a Physical/Scientific/Technological Problem in Mathematical Terms, translating complex concepts into mathematical language.
- Search, Analyze, and Synthesize Data and Information, adapting them to specific scientific problems with necessary and reasonable approximations.
- Combine Knowledge and Skills for the analysis of complex problems, often using suitable approaches and approximations.

(3) COURSE CONTENT

Syllabus:

1. Introduction to basic concepts of quantum mechanics, wavefunctions, operators, propalistic interpretation.

2. Solution of the Schrodinger equation for one-dimensional potentials.

3. Quantum harmonic oscillator, creation-annihilation operator.

4. Central potentials, angular momentum, hydrogen atom.

5. Spin, addition of angular momenta.

6. Time-independent perturbation theory, variational method.

7. Types of chemical bonding in solids.

8. Bravais lattices, reciprocal space.

9. Bloch theorem, k.p method, effective mass.

10. Density of states, total energy.

11. Phonons.

(4) TEACHING AND LEARNING METHODS - ASSESSMENT

TEACHING METHOD *In person, Distance Learning etc.*	In person. In special circumstances, Distance Learning.
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
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	13x4=52 hours
Study	13x4=52 hours
Home Assignments/Exercises	10x4=30 hours
Laboratory	0
Completion/Presentation of Project	0
Educational Visits	0
Examinations	6 hours
Total Course Load	140 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 or English (for Erasmus students: English) **Midterm Exams (problem solving):** 60% of the final grade **Final Written Examination (problem-solving):** 40% of the final grade Explicit mention of these assessment criteria will be made on the Helios platform.

(5) RECOMMENDED BIBLIOGRAPHY

Recommended Bibliography

1) "Quantum Mechanics II", by Stefanos Trachanas (University of Crete Press), in Greek

2) "Atomic and Electronic Structure of Solids", by E. Kaxiras (Cambridge University Press)

3) "Solid State Physics", Volumes 1 and 2, by E. Oikonomou (University of Crete Press), in Greek

4) Lecture material (approximately 250 slides) is available through the Helios electronic platform of the National Technical University of Athens (NTUA).