COURSE OUTLINE

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES			
ACADEMIC UNIT	DEPARTMENT OF MATHEMATICS			
LEVEL OF STUDIES	POSTGRADUATE **Studies in Mathematics**			
COURSE CODE	**B4**		**SEMESTER**	**B**
COURSE TITLE	MATHEMATICAL PHYSICS			

INDEPENDENT TEACHING ACTIVITIES	**WEEKLY TEACHING HOURS**	**CREDITS**
	3	10

COURSE TYPE	SPECIALISED GENERAL KNOWLEDGE
PREREQUISITE COURSES:	NO
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	http://www.math.aegean.gr/index.php/en/academics/undergraduate-programs

(2) LEARNING OUTCOMES

Learning outcomes

The goal of this course is to introduce postgraduate students to the basic concepts and methods of Quantum Mechanics with no prior knowledge of physics. The course gives a comprehensive treatment of Quantum Mechanics and is oriented at mathematical audience.

After completing this course, students should demonstrate competency in the following skills:

- Discover the limitations of the physical laws in applications which stem from the scale of observation.
- Understand the phenomena of microcosmos without having as a reference point their experience in everyday life.
- Acquire mathematical knowledge of new concepts and methods to which they possibly have not exposed before.
- Apply the laws of Quantum Mechanics to solve idealized and realistic problems.
- Model and make predictions about the evolution of a physical phenomenon by solving an ordinary differential equation.
- Evaluate the limitations of the applied mathematical method.
- Propose alternative approaches and decide which method is more effective.

General Competences

Production of free, creative and inductive thinking.
Working independently
Team working
Working in an interdisciplinary environment
Production of new research ideas

(3) SYLLABUS

- States of a system, dynamical laws and observables in Classical and Quantum Mechanics. Experimental evidence and interpretation according to Quantum Mechanics. The correspondence principle and implications.
- Inner product and normed vector spaces. Hilbert space. Orthogonal complements and direct sums. Total orthonormal sets and sequences. Applications to Legendre, Hermite and Laguerre

polynomials. Representation of functionals on Hilbert spaces. The dual of a Hilbert space.

- Bounded operators and the concepts of Hilbert-adjoint, unitary and normal operators.
- Unbounded linear operators in Hilbert space and the concepts of symmetric, self-adjoint and unitary operators. Closed linear operators. The multiplication and differentiation operators.
- The spectrum of operators.
- The necessity of Quantum Mechanics. The Von Neumann's axioms. Mean value and variance of observables.
- Ehrenfest's theorem. Schrödinger and Heisenberg representations.
- Heisenberg's uncertainty principle and consequences. The Hardy's inequality and Quantum Mechanics. Applications.
- The classical and quantum harmonic oscillators. The phase space solution. Creation, annihilation operators and the energy spectrum.
- The virial theorem classically and quantum mechanically. Continuity equation.
- Solving the Schrödinger's equation for a class of potentials in three spatial dimensions.
- Scattering theory in more than two spatial dimensions.
- Tunneling effect. Bound states and potential wells.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY	Face-to-face
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY	• Communication with students via e-mail • Uploading course material on moodle system
TEACHING METHODS	see table below
STUDENT PERFORMANCE EVALUATION	• Students evaluation is based on both homework and a written exam paper consisting on short-answer questions and problem solving • Students with learning disabilities or suffering from serious health problems can alternatively be evaluated through oral exams. • The language of evaluation is Greek.

Activity	***Semester workload***
Lectures	39
Independent study	148.5
Assignments	62.5
Course total (25 per ECTS)	***250***

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

1. S. Weinberg, «Lectures on Quantum Mechanics», Cambridge University Press, 2015.
2. G. Teschl, «Mathematical Methods in Quantum Mechanics: With Applications to Schrodinger operators», Graduate Studies in Mathematics, Vol 157, AMS, 2014.
3. L. A. Takhtajan, «Quantum Mechanics for Mathematicians», Graduate Studies in Mathematics, Vol 95, AMS, 2008.
4. F. A. Berezin and M. A. Shubin, The Schrödinger equation, Kluwer Academic Publishers, 1991.

- Related academic journals:

1. http://aapt.scitation.org/journal/ajp.