COURSE OUTLINE

(1) GENERAL

SCHOOL	FACULTY OF SCIENCES			
ACADEMIC UNIT	PHYSICS			
LEVEL OF STUDIES	GRADUATE			
COURSE CODE	**M111**		**SEMESTER**	**A**
COURSE TITLE	**QUANTUM MECHANICS**			
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**	
		5	10	
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).				
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	General Background			
PREREQUISITE COURSES:				
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek			
IS THE COURSE OFFERED TO ERASMUS STUDENTS				
COURSE WEBSITE (URL)	http://ecourse.uoi.gr/enrol/index.php?id=1399			

(2) LEARNING OUTCOMES

Learning outcomes *The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.* *Consult Appendix A* • *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area* • *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B* • *Guidelines for writing Learning Outcomes*
With the successful completion of the course the graduate student is expected to, 1) obtain a good knowledge of advanced quantum mechanics at both, conceptual and computational level 2) be able to specialize knowledge on specific topics that may even be part of his / her MSc diploma thesis or PhD thesis 3) look for solutions to complex physical systems that meet for the first time after the undergraduate courses, 4) apply new ideas (path integrals, radiation theory, Wigner-Eckart theorem, Bloch waves, etc.) to more specific topics of current research interest (gauge theories, condensed matter physics, atomic and molecular physics, etc) 5) to motivate a better understanding of physical phenomena based on quantum

physics whose conceptual and practical importance are becoming increasingly obvious

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

Search for, production of free, creative and induction thinking, working independently

(3) SYLLABUS

1. Introduction (Orders of magnitude in atomic physics, diffraction and interference of cold neutrons)
2. Mathematics for Quantum Mechanics (Hilbert spaces, Linear Operators, Spectral Decomposition Theorem)
3. Warming up example: spin-1/2 particles (Stern-Gerlach experiment, spin states, Rotation of spin-1/2, Dynamics and Time evolution)
4. Foundations of QM and Postulates (State vectors and physical properties, superposition principle, wave function collapse, measurements, time evolution)
5. Systems of finite number of levels (Elementary quantum chemistry, Nuclear Magnetic Resonance, ammonia molecule and spontaneous symmetry breaking)
6. Entanglement – Bell inequalities (Tensor product, density operator, EPR argument, Bell inequalities)
7. Symmetries (Transformation of a state in a symmetry operation, commutation relations, space translation, time invariance, rotation invariance)
8. Path Integrals
9. Periodic potentials (Bloch theorem, energy bands)
10. Perturbative methods (Time dependent perturbation theory, Fermi's Golden Rule, phase space and density of states, Ionization of Atom by EM field)
11. Angular Momentum (Rotation matrices, orbital angular momentum, generalized angular momentum, addition of angular momenta, Clebsch-Gordan coefficients, Wigner–Eckart theorem and applications)
12. Harmonic Oscillator and Introduction to quantized fields (Coherent states of HO, phonons, scalar field quantization, quantization of electromagnetic field)
13. Scattering (Cross section and scattering amplitude, Scattering at High energies (Born approximation), scattering at low energies (partial wave analysis), Optical theorem, S-matrix, Bound states, Resonances)
14. Interaction of Radiation with Matter (The dipole approximation, the photoelectric effect, quantized EM field: spontaneous emission)

Students pick up projects, for example, from the following pool of subjects with emphasis taken from current front-end research:

- Gravity induced Quantum interference,
- Neutrino Oscillations,

- The system of neutral K-mesons,
- NMR and MRI,
- Decoherence and Measurement problem,
- Spin waves and Magnons,
- Conformal Invariance in Quantum Mechanics,
- Supersymmetry in Quantum Mechanics,
- Helicity amplitudes: two body decays and angular distributions,
- Casimir Effect,
- The Gamow peak,
- Laser cooling and trapping of atoms.
- Open Quantum Systems

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	**Use of ICT in teaching (Moodle system)**
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	see table below
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	1) Weekly Homework problems 2) Written Exams at the end of the course 3) Project: oral and written presentation of a modern Quantum Physics problem

Activity	*Semester workload*
Lectures	65
Study of Bibliography	100
Independent study	46
Essay writing	39
Course total	***250***

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:
- Related academic journals:

- M. Le Bellac, Quantum Physics, Cambridge Univ. Press, 2006.
- G. Baym, Lectures on Quantum Mechanics, Westview Press, (1974).
- S. Weinberg, Lectures on Quantum Mechanics, Cambridge Univ. Press, (2015)

- P. Dirac, The Principles of Quantum Mechanics, Oxford University Press(1988)
- L. Schiff, Quantum Mechanics, McGraw Hill, 1988.
- A. Messiah, Quantum Mechanics, Dover Publications Inc. (2014)
- Kurt Gottfried, Tung-Mow Yan, Quantum Mechanics : Fundamentals, Graduate Texts in Contemporary Physics, 2004.
- J.J. Sakurai, Modern Quantum Mechanics,Addison Wesley; 1 edition (1993)
- J.J. Sakurai, Advanced Quantum Mechanics, Addison Wesley; 1 edition (1967)
- C Cohen-Tannoudji, Quantum Mechanics,Wiley VCH; 1 edition (2006)
- F. S. Levin, Introduction to Quantum Theory, Cambridge Univ. Press (2001)

Books in red are highly recommended.