

COURSE MODULE OUTLINE

General information

SCHOOL	SCHOOL OF SCIENCE & TECHNOLOGY		
PROGRAM COURSE	ADVANCED STUDIES IN PHYSICS		
LEVEL OF STUDY	POSTGRADUATE		
COURSE UNIT CODE	PSF-60		1st
COURSE TITLE	ADVANCED STUDIES IN QUANTUM PHYSICS		
INDEPENDENT TEACHING ACTIVITIES <i>in case credits are awarded for separate components/parts of the course, e.g. in lectures, laboratory exercises, etc. If credits are awarded for the entire course, give the weekly teaching hours and the total credits</i>		WEEKLY TEACHING HOURS	CREDITS
Weekly Teaching hours: 18-19 hours x 30 weeks		560	20
<i>Add rows if necessary. The organization of teaching and the teaching methods used are described in detail under section 4</i>			
COURSE TYPE Compulsory, Optional, Optional mandatory	COMPULSORY		
PREREQUISITE COURSES:	NO		
LANGUAGE OF INSTRUCTION AND EXAMS:	GREEK		
THE COURSE IS OFFERED TO ERASMUS STUDENTS	NO (due the annual duration of the module)		
COURSE WEBSITE (URL)	https://www.eap.gr/en/advanced-studies-in-physics/topics/#p60 Each module has its own space in the Learning Management System of EAP (http://study.eap.gr), with controlled access (use of code) for students and teaching staff.		

(2) LEARNING OUTCOMES

Learning Outcomes

- The course learning outcomes, specific knowledge, skills and competences of an appropriate (certain) level, which students will acquire upon successful completion of the course, are described in detail. It is necessary to consult:

The aim of the module is the development at the postgraduate level of the fundamental principles, methods, and applications of non-relativistic quantum mechanics with the use of

techniques borrowed from linear algebra, operator theory and differential equations in order to solve problems in the field of study of quantum theory.

Upon successful completion of PSF60, students will be able to:

- understand how to apply the laws of quantum physics to the real world.
- acquire the technical skills to solve complex problems.
- analyze a variety of exactly solvable trap and scattering problems
- develop and applies approximate methods to study systems of atomic, molecular, nuclear physics and solid state physics.
- compare theoretical predictions with experimental results.
- evaluate modern results (as analyzed in published scientific articles) based on a broad knowledge of the fundamental laws of quantum physics.

General Competences

Taking into consideration the general competences that students/graduates must acquire (as those are described in the Diploma Supplement and are mentioned below), at which of the following does the course attendance aim?

<i>Search for, analysis and synthesis of data and information by the use of appropriate technologies,</i>	<i>Project planning and management</i>
<i>Adapting to new situations</i>	<i>Respect for diversity and multiculturalism</i>
<i>Decision-making</i>	<i>Environmental awareness</i>
<i>Individual/Independent work</i>	<i>Social, professional and ethical responsibility and sensitivity to gender issues</i>
<i>Group/Team work</i>	<i>Critical thinking</i>
<i>Working in an international environment</i>	<i>Development of free, creative and inductive thinking</i>
<i>Working in an interdisciplinary environment (Other.....citizenship, spiritual freedom, social</i>	<i>.....</i>
<i>Introduction of innovative research</i>	<i>awareness, altruism etc.) </i>

Adapting to new situations
 Decision-making
 Individual/Independent work
 Critical thinking
 Development of free, creative and inductive thinking

(3) COURSE CONTENT

Quantum mechanics is the only existing theoretical framework for the study and interpretation of the entirety of the physical processes that occur at the microscopic level. As such, it occupies a prominent position in modern physics and is one of the greatest scientific advances of the twentieth century. PSF60 focuses exclusively on the subject matter of non-relativistic quantum physics which occurs based on the principle of correspondence, from non-relativistic classical mechanics. This theory is successfully used to describe physical phenomena in the field of (relatively) low energies. High energies require the generalization of the theory in relativistic quantum mechanics, which occurs correspondingly from classical relativistic mechanics, but is not part of the syllabus. The methodology developed in the lessons is based on linear algebra, operator theory, and differential equations that serve the solution requirements of physical problems, as appropriate, but also the mathematical foundation of quantum theory. Problems with exact solutions are described in detail based on the mathematical theory of special functions, while for the rest, approximate solution

methods are introduced and applied (perturbation method, etc.). A crucial aspect of quantum mechanics are symmetries, wherever they exist, and representations of their operators. Physical problems are split into two basic categories: bound state problems and scattering problems, for which the corresponding solution techniques are taught. The primary applications of non-relativistic quantum mechanics concern problems of atomic and molecular physics, quantum optics, quantum chemistry, nuclear physics and solid-state physics, the latter of which exhibits numerous technological applications in everyday life. High-energy processes, such as those found in elementary particle physics, can only be explained by relativistic quantum mechanics and quantum field theory.

All the laws that govern the microcosm are drawn from the basic principles of quantum physics discussed in PSF60.

Detailed Description

- Schrödinger equation – background: the wavefunction, Introductory mathematical notions, the postulates of quantum mechanics, Heisenberg inequalities.
- Simple quantum Systems: harmonic oscillator-coherent states, one dimensional bound state and scattering problems.
- Mathematical formalism of quantum theory: vector spaces, abstract Hilbert spaces, operators on Hilbert spaces, Operators-eigenvalues and eigenstates, Position and Momentum representations of wavefunctions and operators.
- Quantum theory in three dimensions: rotations and angular momentum.
- Schrodinger equation in three dimensions, spherically symmetric potentials, examples and applications, the Hydrogen atom.
- The dynamics of a quantum particle, propagator, Feynman path integrals, density operator.
- Spin, Symmetries, Spherical symmetry, symmetry groups and their representations, angular momentum addition, reflections, parity, time reversal, local gauge symmetry.
- Identical particles.
- Time dependent perturbation theory.
- Scattering: fundamental notions, general theory, scattering matrix, scattering states, scattering for spherically symmetric potentials.

Unit Subjects:

- Quantum Mechanics
- Quantum Chemistry

(4) TEACHING METHODS--ASSESSMENT

MODES OF DELIVERY <i>Face-to-face, in-class lecturing, distance teaching and distance learning etc.</i>	Distance education with six Group Counseling Meetings (OSS) during the academic year on weekends.
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USE OF INFORMATION AND COMMUNICATION TECHNOLOGY <i>Use of ICT in teaching, Laboratory Education, Communication with students</i>	In the meeting and/or in the homework the following are used: • Remote meetings tools (cisco Webex), • Presentation software (e.g. power point), • Graphic tablets - digitizers Additionally, the students use office automation tools, web browsers and e-readers for digital books.												
COURSE DESIGN <i>Description of teaching techniques, practices and methods: Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, Internship, Art Workshop, Interactive teaching, Educational visits, projects, Essay writing, Artistic creativity, etc.</i> <i>The study hours for each learning activity as well as the hours of selfdirected study are given following the principles of the ECTS.</i>	<table border="1"> <thead> <tr> <th><i>Activity/Method</i></th><th><i>Annual workload</i></th></tr> </thead> <tbody> <tr> <td>6 OSS (*4 hours)</td><td>24</td></tr> <tr> <td>Preparation of assignments (6 assignments*20 hours)</td><td>120</td></tr> <tr> <td>Examination</td><td>3</td></tr> <tr> <td>Individual study</td><td>390-436</td></tr> <tr> <td>Total module workload (hours)</td><td>537-583</td></tr> </tbody> </table>	<i>Activity/Method</i>	<i>Annual workload</i>	6 OSS (*4 hours)	24	Preparation of assignments (6 assignments*20 hours)	120	Examination	3	Individual study	390-436	Total module workload (hours)	537-583
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STUDENT PERFORMANCE EVALUATION/ASSESSMENT METHODS <i>Detailed description of the evaluation procedures:</i> <i>Language of evaluation, assessment methods, formative or summative (conclusive), multiple choice tests, short- answer questions, open-ended questions, problem solving, written work, essay/report, oral exam, presentation, laboratory work, other.....etc.</i> <i>Specifically defined evaluation criteria are stated, as well as if and where they are accessible by the students.</i>	Evaluation Language is Greek. Elaboration of written assignments during the academic year, the average of the grades of which participates in the formation of the final grade of module by 30%, if there is a passable in the final or repetitive examinations. In the final written exams the grade of the written assignments participates in the formation of the final grade of module by 70%. All the criteria are posted, both in each written assignment (in the LMS study.eap.gr), as well as in the general regulation of HOU at: https://www.eap.gr/education/study-regulations/												

(5) SUGGESTED BIBLIOGRAPHY:

- Suggested bibliography:

HOU Publications:

Volume A': Quantum Mechanics - Study Manual, HOU, Patras 2005.

Accompanying Text for the module PSF51:

1. Mponatsos, D. Quantum Mechanics II, HOU, Patras 2005.
2. Tsipis, K. Quantum Structure of Chemical Elements, HOU 2001.

Books offered by HOU:

Merzbacher E., *Quantum Mechanics*, 3rd ed., John Wiley & Sons Ltd, 1998.

Alternative teaching material:

In the server <https://apothesis.eap.gr> operates a repository with digital collections of alternative teaching materials.