COURSE OUTLINE

(1) GENERAL

SCHOOL	NATURAL SCIENCES		
ACADEMIC UNIT	DEPT. OF PHYSICS		
LEVEL OF STUDIES	Graduate Course		
COURSE CODE	**M145**	**SEMESTER**	**2**
COURSE TITLE	**Quantum Optics and Lasers**		

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**
	4	7
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*	Specialised general knowledge
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Specialised general knowledge
COURSE WEBSITE (URL)	http://www1.physics.uoi.gr/atomol/index_files/Page3239.htm

(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*

The aim of the course is to provide a basis for the quantum description of optics, lasers, and coherent optical processes. The covered topics include: quantum nature of light, notion of a photon, photon detection processes, coherent and squeezed states of the radiation field, lasers, light- mater interaction and nonlinear optics.

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

- describe optical phenomena using a quantum mechanical formalism,
- understand photon generation and detection,
- apply the quantum description of coherent and partially coherent light in interferometry, quantum measurements, quantum noise, quantum correlations
- understand the bases of laser's operation and their characteristics
- understand light-matter interaction at a microscopic level using semiclassical and quantum theory (two and three-level atomic systems interacting with one or two laser fields)
- understand how a number of indicative modern experiments in quantum optics

are carried out • make quantitative predictions for the outcomes of a number quantum optical experiments

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

(3) SYLLABUS

-Survey of classical optics: electromagnetic fields, polarization, diffraction, interference, coherence, non-linear susceptibility, phase matching
-Response of quantum systems to classical electromagnetic radiation: interaction of a two-level system with incoherent light, the Einstein coefficients, higher-order perturbation theory, multi -photon absorption, non-resonant perturbations, forced oscillations of the atomic dipole moment, frequency mixing, interaction of a two-level system with resonant coherent light, coherent and incoherent processes
-Laser theory: fundamental laser equation, stability analysis, laser threshold, frequency pulling, laser linewidth
-Quantization of the electromagnetic field: Schrodinger equation for a single mode, creation and annihilation operators, the time dependent Schrodinger equation for a single field mode, wave packets, coherent states, time-dependent operators. The Heisenberg picture, the forced harmonic oscillator in the Heisenberg picture, quantization of light field, uncertainty relations and limits of measurability
-Second quantization
-Light /matter interaction: interaction light field—electron wave field, the interaction representation, the dipole approximation, spontaneous and stimulated emission and absorption, perturbation theory , Lamb shift, the dynamic Stark effect
-Quantum theory of coherence: quantum mechanical coherence functions, coherence properties of spontaneously emitted light, quantum beats, squeezed states, quantum noise in amplifiers
- Special topics like: laser cooling and trapping, cold atom systems, the quantum beam splitter, Hanbury Brown and Twiss interferometry, two-photon interferometry....

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to- face
USE OF INFORMATION AND	**Use of ICT in teaching and communication with stu-**

COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	**dents** (http://www1.physics.uoi.gr/atomol/index_files/Page 3239.htm)
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.*	- solving selected problems - essay on an topic -written exams for the evaluation of conclusive understanding and problem solving capabilities

Activity	*Semester workload*
Lectures	52
Tutorials	26
Study of bibliography	47
Non-directed study	47
Exams	3
Course total	***175***

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:
- Related academic journals:

1. H. Haken, Light, Vol. 1 & 2, North Holland (1981)
2. R. Loudon, Quantum Theory of Light (3rd edition), Oxford University Press (2000)
3. M. Fox, Quantum Optics: An introduction, Oxford University press (2006)
4. S. Haroche, J. M. Raimond, Exploring the Quantum, Oxford University Press (2006)
5. H.A. Bachor, T. C. Ralph, A Gide to experiments in quantum optics, Wiley-VCH (2004)
6. P. Meyster, M. Sergent III, Elements of Quantum Optics, Springer-Verlag(1991)
7. M. O. Scully, M. S. Zubairy, Quantum Optics, Cambridge University Press (1997)
8. D.F. Walls, G.J. Milburn, Qunatum optics , Springer-Verlag (1995)

9. M. Fox, Κβαντική Οπτική: μία εισαγωγή, Πανεπιστημιακές Εκδόσεις Κρήτης (2015)
10. J. Wilson, J. Hawkes, Οπτοηλεκτρονική: μία εισαγωγή, Πανεπιστημιακές Εκδόσεις Ε.Μ.Π. (2007)

-Review papers