COURSE OUTLINE

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES		
ACADEMIC UNIT	PHYSICS DEPARTMENT		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	**209**	**SEMESTER**	**7 & 8**
COURSE TITLE	LABORATORY COURSES IN MODERN PHYSICS		

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	6
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*	Special background, skills development
PREREQUISITE COURSES:	Modern Physics I & II Laboratory Courses in Mechanics Laboratory Courses in Electromagnetics Laboratory Courses in Wave Physics and Optics Analog Electronics
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek or English
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	http://ecourse.uoi.gr/enrol/index.php?id=1874

(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*

This course aims to develop students' skills in Experimental Physics. It includes a series of modern experiments that cover knowledge of quantum, optics, optoelectronics, solid state, atomic and molecular physics, nuclear and particle physics. The lab allows students to choose from different experiments. It also emphasizes the self-action of students. Especially after the successful completion of the course the student will be able to:

- Have advanced knowledge of phenomena related to quantum physics through experimental devices such as the Franck-Hertz experiment and the photoelectric phenomenon study.
- Have advanced knowledge in measurement techniques related to light interferometry and holographic imaging.

- Have advanced knowledge on X-ray diffraction and absorption techniques.
- Have advanced knowledge in the measurement techniques relating to the thermal and electrical conductivity of metals as well as the Hall Effect on semiconductors.
- Have advanced knowledge of measuring techniques relating to measurement and characterization of semiconductor devices.
- Have advanced knowledge in the measurement techniques related to optoelectronics and optical fibers.
- Have advanced knowledge in experimental devices and techniques related to the detection of gamma radiation, coincidence measurements and cosmic radiation measurements.
- Have advanced knowledge in detection systems and electronic devices widely used in Experimental Physics.

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*
	Respect for difference and multiculturalism
Adapting to new situations	*Respect for the natural environment*
Decision-making	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Working independently	
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…*
	…….

Team work
Working independently
Search for, analysis and synthesis of data and information, with the use of the necessary technology
Decision-making

(3) SYLLABUS

The course includes the following labs.

- The Franck-Hertz experiment for the verification of the atom's quantum nature
- Emission and absorption spectroscopy. Photoelectric phenomenon. Calibration and use of a spectrometer to characterize a Hg light source. Study of the photoelectric phenomenon, calculation of the Plank constant.
- Michelson Interferometer. Light beam interference, measurement of air refractive index, measurement of light source coherence.
- Holography. Construction of reflection, two beam, rainbow and color holograms. Holographic interferometry.
- X-ray diffraction of crystalline materials. Measurement and analysis of the X-ray diffraction pattern of polycrystalline materials. Reconstruction of the unit cell of the crystalline structure of the material.
- X-ray generation and absorption of materials. Study of X-ray emission and absorption from different materials. Determination of the Plank constant.

- Thermal and electrical conductivity of metals. Measurement of the thermal and electrical conductivity of Al and Cu. Law of Wiedemann-Franz. Calculation of the Lorentz number.
- Semiconductor measurements. Measurement of the specific resistance of various semiconductors (Si, Ge). Measurement of the concentration and the carriers type in p-n contacts. p-n contact potential measurement.
- The Hall Effect in p- and n-Germanium. Measuring the concentration and mobility of carriers in p- and n-Germanium. Measure the Hall coefficient in p- and n-Germanium. Study of the transition from exogenous to endogenous conduction type by increasing the temperature at p- and n-Germanium.
- Optoelectronics. Measure the characteristic I-V for various LED diodes. Measurement of characteristic I / V with / without illumination for one or more photovoltaic Si cells. Study of the LED diode emission spectrum. Measuring the intensity of the light energy in relation to the current through an LED.. Principles of digital telecommunication. Measurement of parameters and Gaussian beam with optical fiber. (Rayleigh parameter, ω_0).
- Optical fibers and sensors. Coupling Gaussian, (Gaussian) laser light beam into a fiber optic. Study and experimentation of fiber optic properties: reflection, bending loss and fiber couplers. Study and calibration of a sensor, bending as a weight sensor. Interferometer Mach-Zehnder as a temperature sensor in water.
- Spectrum gamma spectroscopy with NaI detector. Absorption of gamma rays. Measurement of the energy spectrum of radioactive sources ^{60}Co and ^{137}Cs. Calibration procedure and determination of the geometric performance of the NaI detector. Measurement of the linear absorption coefficient of lead.
- Positron-electron annihilation. Understand the ^{22}Na nuclear diagram. Familiarizing the student with coincidence measurements. Measurement of the ^{22}Na spectrum. Measurement and explanation of the angular distribution of the γ-ray coincidence events (511 keV) corresponding to the positron-electron annihilation.
- Cosmic Radiation - Lifetime of the Muon. Measuring the flow of cosmic muons in the laboratory. Proof of the phenomenon of time dilation. Measuring the angular distribution $(\cos\theta)^2)$ of the cosmic muons. Use of Geiger-Muler and plastic scintillators. Measuring the lifetime of the muon. Calculation of the Fermi G_F coupling constant (weak interaction).

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face learning
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	• All information is provided to the student about the announcements, course scheduling, course regulation, etc through the e-course asynchronous tele-learning system

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- A modern and complete environment is used in the laboratory for the implementation of the laboratory exercises.

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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

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Activity	*Semester workload*
Lectures	12
Laboratory experiments	48
Bibliography study	48
Projects	40
Exams	2
Total	***150***

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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.

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Lab performance (70%) included

- Tests during the execution of each experimental exercise
- Laboratory homework

Written Exam (30%) at the end of the course which includes

- 30% theoretical knowledge test with multiple choice and short answer questions.
- Laboratory work (70%) by performing a part of a laboratory exercise.

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(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:
- Related academic journals:

- Σημειώσεις διδασκόντων (περιλαμβάνουν στοιχεία θεωρίας και περιγραφή της πειραματικής διάταξης και διαδικασίας καθώς και της διαδικασίας ανάλυσης των μετρήσεων για κάθε εργαστηριακή άσκηση).
- "Μαθήματα Οπτικής", Γ. Ασημέλη, Εκδόσεις Σύγχρονη Γνώση(Β' έκδοση, Σεπτέμβριος 2007).
- "Basics of Holography", P.Hariharan, Cambridge University Press (2002).
- "Practical Holography", G.Saxby, S.Zacharovas, 4th Edition, CRC Press (2015).
- "Radiation Detection and Measurement", G.Knoll, 4th Edition, Wiley, ISBN: 978-0-470-13148-0 (2010).
- "Techniques for Nuclear and Particle Physics Experiment", W.R.Leo, ISBN:0-387-57280-5, Springer-Verlang (1994).

- “The Review of Particle Physics”, Particle Data Group, Chin. Phys. C, 40, 100001 (2017) Reviews for Cosmic Rays and Passage of particles through matter.
- “Elements of X-Ray Diffraction” 3rd Ed., B.D. Cullity and S.R. Stock, Pearson Education Ltd 2014.
- "Φυσική Στερεάς Κατάστασης" N.W. Ashcroft and N.D. Mermin, μετάφραση Μ. Καμαράτος Εκδόσεις Α.Γ. Πνευματικός (2012).
- " Semiconductor Physics and Devices Basic Principles" 4th Ed., D.A. Neamen, McGraw Hill 2011.
- "Semiconductor Physics, An Introduction" 9th Ed., K. Seeger, Springer 2004.