COURSE OUTLINE

(1) GENERAL

SCHOOL	School of Science		
ACADEMIC UNIT	Physics		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	**10EK502**	**SEMESTER**	**7**
COURSE TITLE	PHYSICS OF MOLECULES AND NANOMATERIALS		

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**
Lectures (theory and exercises)	4	6

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized
PREREQUISITE COURSES:	No
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes, in the English language for Erasmus students
COURSE WEBSITE (URL)	https://eclass.uoa.gr/courses/PHYS235/

(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 course offers to the student the necessary knowledge for the understanding of basic concepts of physics of molecules and nanomaterials with emphasis on fundamental aspects of molecular bonding and molecular spectra as well as the electronic structure of nanomaterials (graphene and carbon nanotubes). With the completion of the course the student is able to:

- Apply the adiabatic Born-Oppenheimer approximation in order to determine the electronic structure of the hydrogen molecule-ion and hydrogen molecule using molecular orbital (linear combination of atomic orbitals –LCAO) and valence bond theories.
- Analyze the electronic structure (energy diagrams, bonding-antibonding molecular orbitals and terms, HOMO-LUMO, bond order and spin) of diatomic and polyatomic molecules and construct the sp^n hybrid orbitals.
- Describe analytically nuclear motion (rotation, vibration) in diatomic molecules taking into account the effects of centrifugal distortion and anharmonicity and analyze the corresponding molecular spectra (rotational, vibrational and vibration-rotation) in order to calculate experimentally physical quantities of the molecules, such as the moment of inertia and equilibrium bond length.
- Distinguish the fine structure of electronic transitions due to vibrations-rotations and the spectral intensity variation based on the Franck-Condon principle.
- Apply the tight binding method to calculate the energy band structure of one-dimensional chain of atoms, polycatelyne and graphene (π and σ energy bands, linear energy dispersion relation, density of states).
- Describe the electronic band structure of carbon nanotubes (direct-reciprocal lattice, 1^{st} Brillouin zone, zone folding-energy dispersion relation, metallic condition) classify them to metals and semiconductors according to their structural characteristics. Also, distinguish the density of states (Van Hove anomalies) of metallic and semiconducting nanotubes and the corresponding electronic transitions in relation to their diameter.

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…
…….

The course aims at the following general competences:

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Analytical and synthetic thinking
- Critical thinking
- Problem solving

(3) SYLLABUS

- Electronic structure of molecules, molecular binding, the hydrogen molecule, diatomic and polyatomic molecules (molecular orbitals, valence bond method), molecular orbitals hybridization and delocalization.
- Molecular spectroscopy, vibrational and rotational spectra of diatomic and polyatomic molecules, electronic transitions, Frank-Condon principle.
- Physics of nanomaterials, electronic structure of graphene and carbon nanotubes, electronic transitions, van Hove singularities.
- Imaging methods for nanomaterials, atomic force microscopy, tunneling microscopy, near-field optical microscopy.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face Live streaming (distance learning in special circumstances)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Yes Electronic communication with the students using ICT (Information and Communications Technology) Computer-aided lectures, use of Overhead Projectors, eclass platform
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.*	Final written exams in Greek (90%) Writing essays (10%)

Activity	***Semester workload***
Lectures	39
Tutorials	13
Individual Study/ Study and Analysis of bibliography / Preparation	50
Writing reports/ essays	45
Exams	3
Course Total	**150**

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- Notes «Introduction to Molecular Physics», M. Calamiotou, NKUA, 1992, Athens
- Molecular Quantum Mechanics, P.S. Atkins, Editions PAPAZISI, 1999, Athens
- Solid State Physics, H. Ibach, H. Luth, Editions P. & S. ZITI 2011, Thessaloniki

- M. Karplus, R. N. Porter, Atoms and Molecules: An Introduction for Students of Physical Chemistry, W. A. Benjamin, 1970.
- C. N. Banwell, Fundamentals of Molecular Spectroscopy, McGraw-Hill, 1994.
- R. Saito, M. S. Dresselhaus, G. Dresselhaus, Physical Properties of Carbon Nanotubes, London: Imperial College Press, 1998.
- S. Reich, C. Thomsen, J. Maultzsch, Carbon Nanotubes: Basic Concepts and Physical Properties, Wiley-VCH, Berlin, 2004.
- H. Rasa, Graphene Nanoelectronics. Metrology, Synthesis, Properties and Applications, Springer-Verlag Berlin Heidelberg 2012.