COURSE OUTLINE

(1) GENERAL

SCHOOL	School of Science		
ACADEMIC UNIT	Physics		
LEVEL OF STUDIES	Undergraduate (Postgraduate course offered to undergraduate students)		
COURSE CODE	**10EK413**	**SEMESTER**	**8**
COURSE TITLE	**NUCLEAR 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**
Lectures		4	6
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialised Knowledge		
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/PHYS221/		

(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 and methods of Nuclear Physics, starting with the microscopic structure of matter at the level of protons and neutrons, and proceeding to smaller dimensions related to the structure and interactions of the nucleons themselves. In addition, various topics of nuclear physics are developed at a theoretical and experimental level. By successfully attending and completing the course, the student: • Has acquired fundamental knowledge through experimental data and theoretical models to understand the structure of hadrons, nuclei and nuclear matter. • Has gained a clear understanding of the hadronic structure, the experimental evidence for the existence of quarks and the symmetries that govern the classification of hadrons. • Has built a strong foundation of understanding nucleon properties and basic nucleon structure models, including models in the context of Quantum Chromodynamics. • Has a clear understanding of modern theories and properties of nuclear interaction, nucleon-nucleon scattering, phenomenological potentials and meson exchange theories. • Is able to describe microscopic nucleonic systems, such as deuterium, light nuclei and nuclear matter in general. • Has acquired knowledge of nuclear mean field and correlation theories, moving towards the model of shells and active potentials. • Is able to describe nuclei based on the Hartree-Fock theory; to recognize and understand collective phenomena. • Is able to apply the relativistic mean-field model on nuclear systems • Has developed the equation of state of nuclear matter and is able to describe the phases of strongly interacting matter. • Has acquired knowledge of Nuclear Astrophysics (neutron stars, stellar nuclear fusion, etc.)

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 and in groups. • Analytical and synthetic thinking. • Critical thinking. • Problem solving.	

(3) SYLLABUS

1. Study of hadronic structure (8 hours)

Introduction to hadronic structure. Experimental evidence for the existence of quarks. The standard model and properties of hadrons. Symmetries and classification of hadrons.

2. Nucleon physics (12 hours)

Nucleon properties. Nucleon structure modelo. Quantum chromodynamics and nucleon structure.

3. The nuclear interaction (8 hours)

Review of basic features of nuclear interaction. Nucleon-nucleon scattering. Phenomenological potentials and meson exchange theories. Nuclear potentials inspired by quantum chromodynamics and its active theories.

4. Microscopic description of nucleon systems (10 hours)

Deuterium, light nuclei and nuclear matter. Nuclear mean field. Correlation theories. Shell theory and active potentials. Nucleus pairing and polarization. Description of nuclei based on the Hartree-Fock theory.

5. Collective effects (10 hours)

TDA-RPA theories. Relativistic mean field pattern. Mesons and quarks in nuclei. Nuclear equation of state and properties of nuclear matter. Phases of strongly interacting matter.

6. Elements of Nuclear Astrophysics (4 hours)

Neutron stars, stellar nucleosynthesis, etc.

(4) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td>Face-to-face; Via telecom if health safety protocols demand it</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td>Yes

Electronic communication with the students using ICT. Computer-aided lectures, eclass platform, projects with numerical simulations on a computer; Database use and research. Machine Learning methods (on occasion)</td></tr>
<tr><td>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</td><td><table>
<tr><th>Activity</th><th>Semester workload</th></tr>
<tr><td>Lectures</td><td>52</td></tr>
<tr><td>Individual Study/ Study and Analysis of bibliography / Preparation</td><td>48</td></tr>
<tr><td>Projects</td><td>50</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Course Total</td><td>150</td></tr>
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<tr><td>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.</td><td>Final written exams in Greek
Weekly homework
Final term paper and oral presentation

The assessment criteria are explicitly stated in the first lesson at the beginning of the semester.</td></tr>
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(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- S.M. Wong, “Introductory Nuclear Physics”, J. Wiley (1998)
- K. Heyde, “Basic Ideas and Concepts in Nuclear Physics”, IOP (1999), CRC (2004)
- C. Bertulani, “Nuclear Physics in a Nutshell”, Princeton University Press (2009)
- W. Greiner and J.A. Maruhn, “Nuclear Models”, Springer Verlag (1996, 2009)
- A. deShalit and H. Feshbach, “Theoretical Nuclear Physics”, Vol. 1, Wiley (1974)
- P. Ring and P. Schuck, “The Nuclear Many Body Problem”, Springer Verlag (1980, 2004)
- A.G. Sitenko and V. Tartakovskii, “Lectures on the Theory of the Nucleus”, Pergamon (2014)
- A. Bohr and B.R. Mottelson, “Nuclear Structure”, Vol. I, Benjamin (1969,1975)
- T. W. Donnelly et al, “Foundations of Nuclear and Particle Physics” , Cambridge Univ. Press (2017)
- R. Badhuri, “Models of Nucleon”, Addison Wesley (1998)
- A. Thomas, W. Weise, “The Structure of the Nucleon”, Wiley (2001)
- A. Kamal, “Nuclear Physics”, Springer (2014)
- K. Krane, “Introductory Nuclear Physics”, Gutenberg (2021) – Greek translation
- TALENT Courses (Courses 1, 2, 3, 7) (www.nucleartalent.org)
- Various articles and review literature
- Lecture slides and material

- Related academic journals (Indicative list):

- Physical Review C, Physical Review Letters (APS).
- Journal of Physics G (IoP)
- European Physical Journal A (Springer)
- Nuclear Physics A and B (Elsevier)

- Websites (Indicative list):

- National Nuclear Data Center, https://www.nncd.bnl.gov/
- IAEA Nuclear Data Section, https://www-nds.iaea.org
- https://nucleide.org