COURSE OUTLINE

(1) GENERAL

SCHOOL	School of Science			
ACADEMIC UNIT	Physics			
LEVEL OF STUDIES	Undergraduate			
COURSE CODE	**10ΕΛΕ04**		**SEMESTER**	**8**
COURSE TITLE	**GROUP THEORY AND APPLICATIONS**			
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*	General 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/PHYS299			

(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 provides the student with the opportunity to become familiar with basic concepts and theorems of the mathematical Group Theory, as well as to learn methods for systematically solving problems related to the impact of symmetry transforms to the phenomenological properties of physical systems. By successfully attending and completing the course, the student will be able to:

- Understand the origin of conservation laws in Physics.
- Understand in depth properties of operators and their connection to physical observables (angular momentum, spin).
- Use Group theoretical tools to extract spectral properties (eigenvalues, eigenstates) of Hamiltonian operators of quantum systems with specific symmetries.
- Use Group Theory to describe the modes of mechanical systems in symmetric set-ups.
- Use Group Theory to derive selection rules, implied by underlying symmetries, for possible transitions in quantum mechanical systems.

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

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

- Introduction: Symmetry transforms and conservation laws. Definition of a group. Classification of groups, examples. Constructive approach to low-order finite groups.
- Cyclic groups. Rearrangement lemma. Subgroups, cosets, Lagrange theorem.
- Direct product of groups. Homomorphism-isomorphism. Factor groups. Conjugation classes, normalizer.
- Permutation group. Cayley theorem. Young diagrams and Young tableaux.
- Representations of groups. Schur's lemmas. Great Orthogonality Theorem. Character tables. Decomposition of reducible representations. Projection operators, construction of basis functions of irreducible representations.
- Examples and applications in Physics: Bloch's theorem. Symmetry and block-diagonalization in various eigenvalue problems. Degeneracies. Degeneracy lifting due to a perturbation. Irreducible tensor operators, direct product representation, selection rules in optical transitions.
- Continuous groups. The SO(2) group. Lie groups. Lie algebra.
- The SO(3) and SU(2) Lie groups.
- Cartan subalgebra, roots, weights, the SU(N) group, representations, Young tableaux.

(4) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td colspan="2">Face-to-face (Distance learning in special circumstances)</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td colspan="2">Yes

Electronic communication with the students using ICT.
Computer-aided lectures, e-class platform.</td></tr>
<tr><td rowspan="6">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>Activity</td><td>Semester workload</td></tr>
<tr><td>Lectures</td><td>52</td></tr>
<tr><td>Individual Study/ Study and Analysis of bibliography / Preparation</td><td>95</td></tr>
<tr><td>Exams</td><td>3</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Course Total</td><td>150</td></tr>
<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 colspan="2">Written final exam in Greek.</td></tr>
</table>

(5) ATTACHED BIBLIOGRAPHY

Suggested bibliography:

- I. Vergados, Group Theory, volumes A’ and B’, E. Kalamaras Editions, 1991 (in Greek)
- M.S. Dresselhaus, Applications of Group Theory to the Physics of Solids, MIT 2002
- F.W. Byron and R.W. Fuller, Mathematics of Classical and Quantum Physics, Dover, 1992

Instructors’ notes and plenty of notes online.