COURSE OUTLINE

(1) GENERAL

SCHOOL	School of Science		
ACADEMIC UNIT	Physics		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	**10ΕΛΕ02**	**SEMESTER**	**8**
COURSE TITLE	**Stochastic Processes in 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 (theory and exercises)	4	6

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	General Knowledge
PREREQUISITE COURSES:	No
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek (occasionally English for ERASMUS students)
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	https://eclass.uoa.gr/courses/PHYS246/

(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 this course is to introduce the student to stochastic processes and their relevance in physical phenomena. After an introduction to probability theory and estimation theory, the student is exposed to the concept of random walks, where the analysis focuses on their properties and the importance of dimensionality. Taking the continuum limit, the concept of Brownian motion is introduced. Its properties are analyzed using stochastic differential equations, and the corresponding Fokker-Planck equation. Finally, Brownian path-integrals are introduced and their relationship with quantum mechanics are analyzed.

With the completion of the course the student is able to:

- master the basic concepts of probability and estimation theory;
- understand the concepts behind the central limit theorem, as well as the criteria for its failure;
- explain the role of dimensionality in the properties of random walks;
- understand the notion of Brownian motion and its applications
- use the tools and methodologies of Brownian motion to solve advanced problems by first finding the correct differential equations, and then solving them;
- understand the concept of Brownian path-integrals and where they are applicable;
- solve simple problems in probability, estimation and detection
- solve first passage time problems using the diffusion equation with various boundary conditions
- apply techniques from stochastic processes in a wide range of situations;
- use the tools, methodologies, language and conventions of stochastic processes to test and communicate ideas and explanations not only in Physics but in other fields as well;

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…*
	…….

By successfully attending and completing the course the student will acquire the following skills:

- Ability to search, analyze and compose data and information, using the appropriate technological tools.
- Ability to work autonomously.
- Train free, creative and inductive thinking.
- Train analytical and synthetic thinking.
- Ability to solve problems.
- Ability to making a convincing presentation of a technical subject and the ability to think on their feet, answering questions on the material

3. SYLLABUS

- Introduction: Random variables, distributions, moments, moment generating function, Bayes Theorem.
- Estimation Theory: Hypothesis testing, estimation of variables using MMSE, MAP
- Central Limit Theorem: proof, examples where it fails (Cauchy)
- Discrete random walks: Fundamental equation, Polya Theorem, Mean number of distinct sites visited
- Levy processes
- Diffusion Equation: Properties, Probability Current, Boundary conditions, First passage time calculation
- Green's function
- Brownian motion: Properties, nondifferentiability, Ito – Stratonovich differences
- Stochastic Diff. Equation
- Fokker Planck Equation: Properties
- Ornstein-Uhlenbeck Process – Langevin Equation
- Classical Caldeira – Leggett Model
- Introduction to Brownian path integrals: Feynman - Kac formula, Derivation, Applications

(3) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face
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, e-class 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.*	Homeworks Presentation at the end of the semester on an application of the course material in a real physical situation

Activity	Semester workload
Lectures/ exercises	52
Individual Study/ Study and Analysis of bibliography / Preparation	98
Course Total	**150**

(4) ATTACHED BIBLIOGRAPHY

- Α. Παπούλης, «Πιθανότητες, Τυχαίες Μεταβλητές και Στοχαστικές Διαδικασίες», McGraw Hill.
- Itzykson, Drouffe, “Statistical Field Theory”, Cambridge University Press
- H. Risken, “The Fokker-Planck Equation”, Springer Verlag
- D. Lemons, “Introduction to Stochastic Processes in Physics”, J. Hopkins University Press
- W. Paul, J Baschnagel, “Stochastic Processes, from Physics to Finance”, Springer Verlag
- Selected Journal Papers