UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

DIPARTIMENTO INTERUNIVERSITARIO DI FISICA

General information	
Academic subject	PROBABILISIC METHODS of PHYSICS (SSD MAT/06)
Degree course	Physics
Academic Year	2022-23
European Credit Transfer and Accumulation System (ECTS)	6
Language	ENGLISH
Academic calendar (starting and ending date)	I year, II semester (06/03/2023 - 09/06/2023)
Attendance	Not compulsory

Professor/ Lecturer	
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Department and address	Department of Physics - via Amendola 173, 70125 Bari
Virtual headquarters (Microsoft Teams code)	Teams code: zrq4qag
Tutoring (time and day)	Monday, 10:30 - 12:30

Syllabus	
Learning Objectives	Essentials of Probability. Stochastic processes. Markov processes. Forward equations. Stochastic differential equations. Brownian motion. Stochastic mechanics
Course prerequisites	Differential and integral calculus; Complex variables functions
Contents	**PROBABILITY** **1. Probability spaces**: samples, events, probability, conditioning and independence. **2. Probability measures**: 2.1. probability on finite or countable spaces 2.2. probability on **R**: distributions, densities, mixtures 2.3. probability on $\mathbf{R}^n$: multivariate distributions; marginals; copulas 2.4. probability on $\mathbf{R}^\infty$ and $\mathbf{R}^T$ **3. Random variables** 3.1. laws and distributions; combinations of r.v.'s 3.2. random vectors; independence; expectation, covariance 3.3. conditioned distributions and expectations; examples 3.4. functions and sums of independent r.v.'s **4. Limit theorems** 4.1. characteristic functions; moments, Gaussian laws 4.2. Gaussiani limit theorems 4.3. Poisson theorem 4.4. Large numbers law **STOCHASTIC PROCESSES** **5. Generalities**: laws; convergence; stationarity, ergodicity, power spectrum **6. Sample trajectories**: Poisson and Wiener processes; white noise; Brownian motion **7. Markov processes**: 7.1. Markovianity 7.2. stationarity, omogeneity, ergodicity 7.3. independent increments 7.4. jump-diffusion processes 7.5. evolution equations, particular exemples **8. Elements of stochastic calculus** 8.1. motivations 8.2. stochastic integrals 8.3. stochastiche differential equations; exemples and solutions **PHYSICAL MODELING**

	9. Dynamical theories of Brownian motion 9.1. free particles; force fields; Markovianity 9.2. invariant laws; Boltzmann distribution **10. Stochastic mechanics**: 10.1. retarded and advanced equations 10.2. kinematics and dynamics of a diffusion process 10.3. Schrôdinger equation
Books and bibliography	N. Cufaro Petroni: Probability and Stochastic Processes for Physicists (Springer 2020)
Additional materials	None

Work schedule			
Total	Lectures	Hands on (Laboratory, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
Hours			
150	40	15	95
ECTS			
6	5	1	

Teaching strategy	
	Lectures either in a teaching room with the aid of a laptop and a projector, or online with Teams

Expected learning outcomes	
Knowledge and understanding on:	Ability to structure probabilistic models in order to interpret and model complex random, and time depending physical phenomena
Applying knowledge and understanding on:	Ability to apply the stochastic calculus and the main filtering procedures for random signals
Soft skills	• *Making informed judgments and choices* Ability to work in growing autonomy, even with responsibilities for project planning and structure management • *Communicating knowledge and understanding* Acquisition of communication proficiency in Italian and English; ability to work in interdisciplinary teams, with a wording flexibility suitable to an intercultural environment • *Capacities to continue learning* Acquisition of basic tools for a lifelong updating of the personal learning. Ability to look at the bibliographies and databases available on the web

Assessment and feedback	
Methods of assessment	Final oral examination (100%), with a possible intermediate test (50%)
Evaluation criteria	• *Knowledge and understanding* ○ The student must know the fundamentals of probability, the concepts of random variable and stochastic process, the main classical limit theorems • *Applying knowledge and understanding* ○ The student must know and know how to use the process evolution equations in the form of both PDE's and SDE's, the stochastic differential calculus. The student must know the Brownian motion and the stochastic mechanics • *Autonomy of judgment* ○ The student should be able to choose the right mathematical tool to tackle a problem in random processes • *Communicating knowledge and understanding* ○ The student should be able to work in Italian and English in interdisciplinary teams, with a wording flexibility suitable to an intercultural environment

	• *Capacities to continue learning* ○ The student should be able to update his personal learning, and to look at the bibliographies and databases available on the web
Criteria for assessment and attribution of the final mark	Check of the acquired knowledge and the communication skills
Additional information	