COURSE OF STUDY *Physics (LM-17)*

ACADEMIC YEAR *2024-2025*

ACADEMIC SUBJECT *Random Matrix Theory*

General information	
Year of the course	2nd
Academic calendar (starting and ending date)	1st semester: September - December 2024
Credits (CFU/ECTS):	3
SSD	MAT/07
Language	English
Mode of attendance	Recommended, not mandatory

Professor/ Lecturer		
Name and Surname	Giovanni Gramegna (Module coordinator)	Fabio Deelan Cunden
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Department and address	Physics Department, Room R08 (Raised floor)	Department of Mathematics, office 22 second floor
Virtual room	https://www.uniba.it/it/docenti/giovanni-gramegna	https://www.dm.uniba.it/it/members/cunden
Office Hours (and modalities: e.g., by appointment, on line, etc.)	By appointment via email, in person or via teams	By appointment via email

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
75	16	15	44
CFU/ECTS			
3	2	1	

Learning Objectives	*This course is an introduction to the theory and applications of random matrices*
Course prerequisites	*Linear algebra, Probability theory, Quantum mechanics, Statistical mechanics*

Teaching strategies	*In-class lectures (blackboard and beamer).*
Expected learning outcomes in terms of	
Knowledge and understanding on:	Understanding of fundamental concepts and strategies for the study of random matrices and related models. Learning of appropriate proof techniques, calculation methods and applications. Acquisition and mastery of the definitions and theoretical results covered by the course.
Applying knowledge and understanding on:	Ability to apply the acquired theoretical knowledge to the study of complex systems modeled by random matrices.
Soft skills	**DD3** Making judgments: critical approach to concepts, ability to choose solution methods and ability to provide examples and counterexamples.

	DD4 Communication skills: mastery of language and quality of presentation. Ability to learn: ability to organize knowledge, critical reasoning and possible independent study. **DD5** Capacities to continue learning: Acquisition of basic tools for a lifelong updating of personal learning. Ability to look at the bibliographies and databases available on the web
Syllabus	*This course is an introduction to the theory of random matrices, one of the most active research topics in contemporary mathematical physics and probability. In addition to its intrinsic mathematical appeal, interest in random matrices has been spurred by the scientific hypothesis that large random matrices yield models for complex systems composed of many highly correlated components. Such systems are ubiquitous in mathematics and nature (energy levels of heavy nuclei or chaotic quantum billiards, zeros of L-functions, random growth models, etc.) but are not within the purview of classical scalar probability theory, whose limit theorems usually apply to systems of weakly correlated components. Topics covered will include:* *- brief history of random matrix theory;* *- basic objects and questions;* *- the main limit theorems;* *- connections to other areas of mathematics and science;* *-classical matrix models (Gaussian and unitary);* *- semicircular law;* *- determinantal point processes, orthogonal polynomials and scaling limits;* *- gap probabilities;* *- statistics of the largest eigenvalue and Tracy-Widom distributions; - log-gas and the equilibrium measure;* *- non-hermitian random matrices.*
Content knowledge	
Texts and readings	1. M. L. Mehta, Random Matrices, 1967. 2. G. W. Anderson, A. Guionnet, O. Zeitouni, An introduction to Random Matrices, 2005. 3. P. J. Forrester, Log-gases and Random Matrices, 2010. 4. T. Tao, Topics in Random Matrix Theory, 2012. 5. G. Livan, M. Novaes, P. Vivo, Introduction to Random Matrices-Theory and Practice, 2018.
Notes, additional materials	
Repository	*E-learning system at dm.uniba.it*

Assessment	
Assessment methods	*Two alternatives are available to the student to pass this exam:* *1) Paper presentation. Students present the content of 1-2 papers suggested by the lecturers.* *2) A small project to present and implement ideas on a topic suggested by the lecturers.*
Assessment criteria	Knowledge and understanding: acquisition and mastery of the definitions and theoretical results covered by the course. Applied knowledge and understanding: ability to apply the acquired theoretical knowledge to the study of systems modeled by random matrices. Making judgments: critical approach to concepts, ability to choose solution methods and ability to provide examples and counterexamples.

	Communication skills: mastery of language and quality of presentation. Ability to learn: ability to organize knowledge, critical reasoning and possible independent study.
Final exam and grading criteria	The final mark is expressed out of thirty. The minimum mark to pass the exam is 18/30.
Further information	
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