



Course unit English denomination	Advanced Topics in Complex Networks
Teacher in charge (if defined)	● Prof. Manlio De Domenico (chair) ● Dr. Johannes Nauta ● Dr. Charley Presigny ● Dr. Tomas Scagliarini
Teaching Hours	24
Number of ECTS credits allocated	3
Course period	02/2025 – 06/2025
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (50% minimum of presence) ☐ No
Course unit contents	1. Networks in physical, biological and socio-ecological systems 2. Definitions, Representation and fundamental operators 3. Network ensembles 4. Dynamical processes (Reaction-diffusion on networks; Epidemic models; Metapopulation models; Simple vs Complex contagion processes) 1. Interplay between structure and dynamics (Latent geometry of information propagation; Thermodynamic approach: propagators, density matrix, information) 1. High-order mechanisms and behaviors 2. Multilayer networks (Structure: tensorial formulation; Dynamics: diffusive processes; Intertwined dynamics in multilayer networks; Robustness/Fragility of multilayer networks/independent systems; Reconstruction of complex networks from observational data)
Learning goals	The student will acquire new competences in the emergent field of Network Science and how to model and analyze networks from a physics perspective. The student will develop the following abilities: a) Model a complex system as a complex network and apply this knowledge to a set of empirical systems b) Analyze the structure of a complex network c) Analyze dynamical processes on the top of a complex network d) Reconstruct a complex network from the observation of observables changing over time
Teaching methods	Theory Lectures. Possibly, carrying out (in small groups) of simple computational projects.



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Course on
transversal,
interdisciplinary,
transdisciplinary
skills

☒ Yes

☐ No

Available for PhD
students from other
courses

☒ Yes

☐ No

Prerequisites
(not mandatory)

Statistical mechanics; nonlinear dynamics; physics of complex networks (basics)

Examination
methods
(if applicable)

Discussion about a topic agreed with the professor

Suggested readings

“Physics of complex networks”, notes provided by the professor

Additional
information

NA
