UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

DIPARTIMENTO INTERUNIVERSITARIO DI FISICA

| **General information** | | |
|---|---|---|
| Academic subject | Modelling of Complex Systems | |
| Degree course | Physics | |
| Academic Year | 4 | |
| European Credit Transfer and Accumulation System (ECTS) | 6 | |
| Language | English | |
| Academic calendar (starting and ending date) | II semester | |
| Attendance | Recommended | |

| **Professor/ Lecturer** | |
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| Name and Surname | Nicola Amoroso |
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| Telephone | 0805442551 |
| Department and address | *Farmacia – Scienze del Farmaco, stanza 514 bis, IV piano* |
| Virtual headquarters (Microsoft Teams code) | *qh43wj4* |
| Tutoring (time and day) | Monday and Friday (on request) |

| ***Syllabus*** | |
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| Learning Objectives | *Fundamentals of graph theory and its applications to real systems* |
| Course prerequisites | *None* |
| Contents | *Graph theory: from basic definitions to networks' algebra. The Laplacian matrix, eigenvalues and eigenvectors. Network Models. Random graphs: the Erods-Renyi model. Random matrix theory. Small-world networks. Scale-free networks. Structural and topological property of a network. From global to nodal properties: node centrality. Community detection. Weighted networks: an outline. Laboratory: Programming applications with Python to real-world networks. Case study (to be discussed with the student)* |
| Books and bibliography | • *"Complex Networks: Principles, Methods and Applications", V. Latora, V. Nicosia, G. Russo (Cambridge University Press, 2017)*<br>• *"The structure of Complex Networks", E. Estrada (Oxford University Press, 2016)* |
| Additional materials | |

| **Work schedule** | | | |
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| Total | Lectures | Hands on (Laboratory, working groups, seminars, field trips) | Out-of-class study hours/ Self-study hours |
| **Hours** | | | |
| 100 | 32 | 16 | 52 |
| **ECTS** | | | |
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| **Teaching strategy** | |
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| | Frontal lessons, group exercises, focus groups and discussion |

| **Expected learning outcomes** | |
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| Knowledge and understanding on: | • Basic concepts of complex networks and graph theory communication skills;<br>• computer skills related to (big) data analytics;<br>• scientific programming (Python);<br>• data/results visualization with appropriate scientific language;<br>• ability to work in a group. |

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| Applying knowledge and understanding on: | • Modelling real systems with complex networks and using network-based measurements for statistical learning<br>• Ability to understand the underlying dynamics of complex systems |
| Soft skills | • **Making informed judgments and choices**<br>○ The application of complexity principles to different fields: biology, medicine, …<br>○ The use of complexity techniques in real contexts<br>• **Communicating knowledge and understanding**<br>○ To evaluate the language soundness and the rigor;<br>○ To organize and discuss a hypothesis-test-result framework<br>• **Capacities to continue learning**<br>○ Mathematics of graph theory<br>○ Problem solving strategies<br>○ Modelling real systems |

| **Assessment and feedback** | |
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| Methods of assessment | Oral presentation of a case-study |
| Evaluation criteria | • **Knowledge and understanding**<br>○ Consistency of answers according to formulated questions<br>• **Applying knowledge and understanding**<br>○ Setting up and carrying out numerical examples<br>• **Autonomy of judgment**<br>○ Consistency with the subject of the program<br>○ Software debug<br>• **Communicating knowledge and understanding**<br>○ Clarity and precision of presentation<br>• **Communication skills**<br>○ Ability to identify interconnection between the subjects of study<br>• **Capacities to continue learning**<br>○ Cross-discipline applications |
| Criteria for assessment and attribution of the final mark | Conciseness<br>Rigor<br>Reproducibility of results |
| **Additional information** | |
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