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Short description of the courses given throughout the project and related scientific fields

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Courses common to all disciplines

- Introduction to Complex Science
- Complex Science II
- Introduction to Networks
- Dynamics and Evolution of Complex Networks

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Course 1
Introduction To Complex Science

1. What is Complexity Science?
2. Elementary Statistical Physics
3. Phase Transitions
4. Diffusion Theory
5. Percolation Theory

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COURSE 1. Introduction To Complex Science

Lesson 1: What is Complexity Science?

- What is a Complex system?
- Historical background
- Where do we meet Complex systems?
- Why is Complexity Science useful?

Lesson 2: Elementary Statistical Physics

- Introduction to Statistical Physics
- Probability theory fundamentals
- The Distribution function
- Statistical Ensembles

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COURSE 1. Introduction To Complex Science

Lesson 3: Phase Transitions

- Phase transitions in nature
- What is a phase transition?
- First and second order transitions

Lesson 4: Diffusion Theory

- Diffusion in Materials
- Diffusion in Complex systems
- Diffusion in man made systems

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COURSE 1. Introduction To Complex Science

Lesson 5: Percolation Theory

- What is percolation theory?
- Percolation in nature
- Percolation in Complex systems

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Course 2
Complex Science II

1. Randomness and Random Numbers
2. Monte Carlo Simulations
3. Random Walk
4. The Trapping problem
5. Percolation in Lattices
6. Molecular Dynamics

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COURSE 2. Complex Science II

Lesson 1: Randomness and Random numbers

- Randomness in nature
- What is a random number?
- Generation of random numbers

Lesson 2: Monte Carlo Simulations

- Stochastic modeling
- What is Monte Carlo simulation?
- Why is Monte Carlo useful?

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COURSE 2. Complex Science II

Lesson 3: Random Walk

- Simulate lattices (dimensions, shapes)
- Boundary conditions
- What is Random Walk?
- Biased Random Walk

Lesson 4: The trapping problem

- What is a trap?
- Random traps in lattices
- Random walk with traps

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COURSE 2. Complex Science II

Lesson 5: Percolation in lattices

- Clusters in lattices
- Percolating clusters
- Spanning cluster
- The percolation transition

Lesson 6: Molecular Dynamics

- Basics of molecular dynamics
- Nonequilibrium dynamics
- Rigid molecules
- Flexible molecules

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Course 3
Introduction to Networks

1. Topology of Real networks
2. Introduction to graph theory
3. Random Networks / Scale free networks
4. Robustness and Tolerance of networks
5. Simulation Techniques

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COURSE 3. Introduction to Networks

Lesson 1: Topology of real networks

- World Wide Web/Internet
- Movie actor/science collaboration networks
- Biological/ecological networks
- Linguistic networks

Lesson 2: Introduction to graph theory

- Random Graphs (basic principles)
- Nodes - links
- Directed links
- Bipartite graphs

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COURSE 3. Introduction to Networks

Lesson 3: Random / Scale-free Networks

- Random Networks characteristics
- Scale – Free Networks characteristics

Lesson 4: Simulation Techniques

- Methods for network simulation
- Accuracy and comparison to real world networks

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COURSE 3. Introduction to Networks

Lesson 5: Robustness and Tolerance of networks

- Robustness in various types of networks (communication, cellular, Ecological)
- Error tolerance
- Attack tolerance

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Course 4
Dynamics and Evolution of Complex Networks

1. Preferential attachment
2. Growth
3. Local events
4. Competition in evolving networks
5. Diffusion/Percolation in Random Networks

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COURSE 4. Dynamics and Evolution of Complex Networks

Lesson 1: Preferential attachment

- Measuring preferential attachment
- Nonlinear preferential attachment
- Initial attractiveness

Lesson 2: Growth

- Effect of nonlinear growth rates on dynamics and topology of real world systems
- Analytical approach of growth
- Growth constraints

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COURSE 4. Dynamics and Evolution of Complex Networks

Lesson 3: Local Events

- Internal edges and rewiring
- Internal edges and node removal

Lesson 4: Competition in evolving networks

- Fitness model
- Edge inheritance

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COURSE 4. Dynamics and Evolution of Complex Networks

Lesson 5: Diffusion/Percolation in Random Networks

- Walking on a network
- Attaching to edges
- Infinite dimensional percolation
- Parallels between graph theory and percolation

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Outline of courses
Specific to each discipline

- We will finalize the fields and the courses based on info provided by you
- We value your input
- We suggest the following fields
- You can suggest more …

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Courses 5-7
Specific Fields Related Courses

1. Sociophysics
2. Econophysics
3. IT Research
4. Language Evolution
5. YOUR SUGGESTION COULD BE HERE

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COURSES 5-7. Specific Fields Related Courses

Sociophysics Course: Indicative material

- Hate/friendship networks (online or real world)
- Collaboration networks (scientific, actor etc)
- Rumor spreading in social networks
- Disease/Epidemic spreading in sexual networks

Econophysics Course: Indicative material

- Market risk measurement
- Credit risk measurement
- Derivatives pricing
- Stock and stock market interdependencies

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COURSES 5-7. Specific Fields Related Courses

IT Research Course: Indicative material

- Virus spreading in communication networks
  - SIS model
  - SIR model
- Targeted attacks in communication networks

Language Evolution Course: Indicative material

- Vocabulary evolution
- Language evolution
- Language competition

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Courses 8-10
Introduction to Programming Courses

1. Programming in C/C++/C+
2. Programming in Fortran
3. Programming in Java

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Additional Courses and Educational Material

1. Mid level programming
2. Scientific programming
3. Student courses
4. e-courses

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Additional Courses and Educational Material

Mid level programming: Indicative material

- Series of lectures on the implementation of Monte Carlo and network algorithms for the simulation of systems exhibiting features described in the previous courses (trapping, percolation, network evolution etc).

Scientific programming: Indicative material

- Series of lectures on the efficient usage of Grid infrastructure to perform large scale simulations, including bash shell scripting, job submission procedure (simple, parametric or parallel), etc.

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Additional Courses and Educational Material

Student Courses: Indicative material

- Series of lectures with a summary of the material of all previous courses. The lectures will focus mainly on the educational aspect of all subjects and not in the research one

e-courses: Indicative material

- supplementary e-courses on all fields
- e-material for practice

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