**Language of Instruction:** English  
**Professor:** Jordi Garcia Ojalvo  
**Professor’s Contact:** jordi.g.ojalvo@upf.edu  
**Office Hours:** by appointment  
**Course Contact Hours:** 15 hours  
**Recommended Credit:** 2 ECTS credits  
**Weeks:** 1  
**Course Prerequisites:** Students should have completed first-year mathematics courses (calculus and algebra) from any scientific or technical degree (including, but not limited to, Biology, Computer Science, Physics, Mathematics, and Industrial Engineering)  
**Language Requirements:** The course will be taught in English, but students will be able to communicate (orally and in writing) also in Spanish or Catalan. Thus only oral understanding of English is necessary.

**Time modules:**  
- 2-hour lectures daily, Monday to Friday, from 9h to 11h  
- 1-hour practical sessions daily, Monday to Friday, from 13h to 14h

**Course Description**  
The goal of this course is to introduce biology students to the mathematical modeling of living processes from a systems perspective. According to this perspective, biological processes emerge from the interaction between different elements, be them genes and proteins in the case of cellular processes; cells in the case of tissues; organs in the case of organisms and organisms in the case of ecosystems. We will learn how to represent these interactions mathematically, how to simulate them in a computer, and how to generate predictions that can be compared with reality.

**Keywords:** Genetic circuits, population dynamics, differential equations, computational biology, non linear dynamical systems, synthetic biology.

**Learning Objectives**  
At the end of the course, the student will have learned:  
- to model a variety of biological processes using differential equations  
- to solve these differential equations in a computer (in Python)  
- to interpret biologically the results obtained through their simulations

**Course Workload**  
The course is divided into lectures and programming practical sessions. Students should review and study at home the material taught in the lectures, and finish working on the computer practicals on their own (at least one hour per contact hour).

**Methods of Instruction**  
The lectures will be highly interactive, including group discussions, peer-instruction questions, and computer demonstrations. Students are encouraged to bring their laptops to the lectures, to implement the computer demonstrations on their own. Practical sessions will be hands-on, with students implementing their codes in Python.
Method of Assessment
- Class Participation: 30 percent
- Practical report: 30 percent
- Exam: 40 percent

Absence Policy
Attending class is mandatory and will be monitored daily by the professor. The impact of absences on the final grade will be announced soon.

<table>
<thead>
<tr>
<th>Absences</th>
<th>Penalization</th>
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<tr>
<td>One (1) to two (2) absences</td>
<td>2 points subtracted from final grade (on a 10 point scale)</td>
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<tr>
<td>Three (3) absences</td>
<td>3 point subtracted from final grade (on a 10 point scale)</td>
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<tr>
<td>Four (4) absences</td>
<td>4 points subtracted from final grade (on a 10 point scale)</td>
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<tr>
<td>Five (5) absences or more</td>
<td>The student receives an INCOMPLETE for the course</td>
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The BISS attendance policy does not distinguish between justified or unjustified absences. The student is deemed responsible to manage his/her absences.

Emergency situations (hospitalization, family emergency, etc.) will be analyzed on a case by case basis by the Academic Director of the UPF Summer School.

Classroom Norms
- No food or drink is permitted.
- There will be a ten-minute break during the class.
- Students must come to class having studied at home the content of the previous classes.

Course Contents

Session 1: Systems biology and mathematical modeling (Monday, July 9th)
Life as a systems-level property
Emergent behavior of networks
Introduction to dynamical modeling: the logistic model

Session 2: Population modeling: ecosystems (Tuesday, July 10th)
Population dynamics of interacting species: the Lotka-Volterra model
Coexistence of species as an instance of multistability
Extinction as a result of a transcritical bifurcation

Session 3: Cell modeling: the neuron (Wednesday, July 11th)
Electrophysiology of neurons: the integrate-and-fire model
Neuronal spiking as an instance of excitability
Tonic and random firing: reliability
From neurons to the brain

Session 4: Organ modeling: the heart (Thursday, July 12th)
Spatiotemporal dynamics of heart tissue: Barkley’s model
Tachycardia as a spiral wave-pinning problem
Spiral breakup and ventricular fibrillation
Session 5: Gene modeling: embryonic development (Friday, July 13th)
Cellular decisions in the early embryo
Mutual-inhibition switching as a mechanism of cell-fate decision

Required Readings
The professor will provide a collection of review and opinion research articles that summarize the status of the field.

Recommended bibliography
Students are encouraged to consult the following sources on their own.


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