

BIO-341

**Dynamical systems in biology**

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Cursus	Sem.	Type
Life Sciences Engineering	BA5	Obl.
Systems Engineering minor	H	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
<b>Hours</b>	<b>4 weekly</b>
Courses	2 weekly
Exercises	2 weekly
<b>Number of positions</b>	

**Summary**

Life is non-linear. This course introduces dynamical systems as a technique for modelling simple biological processes. The emphasis is on the qualitative and numerical analysis of non-linear dynamical models. Examples are taken from biology and population models.

**Content**

1. Dynamical systems in 1D
  1. Introduction to dynamical systems, ordinary first-order differential equations in 1D.
  2. Linear stability analysis in 1D. Population dynamics in 1D.
  3. Bifurcations in 1D.
  4. Bistable gene expression and hysteresis in 1D.
2. Dynamical systems in 2D
  1. Linear 2D systems, stability and classification of fixed points, phase portraits.
  2. Non-linear 2D systems, numerical analysis.
  3. Predator-Prey models
  4. Limit cycles and Poincaré-Bendixson theorem, oscillators.
  5. Forced and coupled oscillators, phase oscillators.
3. Discrete dynamical systems
  1. Iterative maps in 1D, Logistic map, numerical analysis.
  2. Period doubling and the route to chaos.

**Keywords**

Non-linear dynamical systems; ordinary differential equations; qualitative analysis; numerical analysis, simulations; population models; bistability and hysteresis; biological oscillators; iterative maps in 1D, chaos and fractals.

**Learning Prerequisites****Required courses**

Informatics 1, II, III  
 Analysis I, II  
 Linear Algebra  
 Numerical Analysis

**Recommended courses**

Physics I, II

### Important concepts to start the course

Analysis and linear algebra  
Basic chemical kinetics

### Learning Outcomes

By the end of the course, the student must be able to:

- Explain simple dynamical models (terms and parameters)
- Analyze dynamical models in 1D
- Analyze models in 2D including phase portraits
- Characterize fixed points and their stability
- Implement simulations of models
- Identify bifurcations in 1D models
- Model biochemical reactions
- Construct simple models
- Critique simple models

### Transversal skills

- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Write a scientific or technical report.
- Demonstrate the capacity for critical thinking

### Teaching methods

Lectures  
Exercises

### Expected student activities

Learn the theoretical material in the lectures  
Solve the exercises using pencil and paper, and implement numerical analysis of models

### Assessment methods

Written examination and graded exercises.

### Supervision

Office hours	No
Assistants	Yes
Forum	Yes

### Resources

#### Bibliography

S. H. Strogatz Nonlinear dynamics and chaos (CRC Press)  
J. D. Murray Mathematical Biology (Spring)

#### Ressources en bibliothèque

- [Strogatz, Nonlinear dynamics and chaos \(CRC Press\)](#)

- [Murray, Mathematical Biology \(Spring\)](#)

**Notes/Handbook**

Course notes in pdf format

**Moodle Link**

- <https://go.epfl.ch/BIO-341>