BIO-341

Dynamical systems in biology

Naef Felix, Shillcock Julian Charles

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
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

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 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 simulations

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)

Notes/Handbook

Course notes in pdf format

Moodle Link

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