COM-502

Dynamical system theory for engineers

Thiran Patrick

Cursus	Sem.	Type
Biocomputing minor	H	Opt.
Bioengineering	MA1, MA3	Opt.
Computational Neurosciences minor	H	Opt.
Computational science and Engineering	MA1, MA3	Opt.
Computer science	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.
Sciences du vivant	MA1, MA3	Opt.
Systems Engineering minor	H	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Courses	2 weekly
Exercises	1 weekly
Number of positions	

Summary

Linear and nonlinear dynamical systems are found in all fields of science and engineering. After a quite thorough review of linear system theory, the class will explain and develop the main tools for the qualitative analysis of nonlinear systems, both in discrete-time and continuous-time.

Content

• **Introduction:** Dynamics of linear and non linear systems. Definitions; Unicity of a solution; Limit Sets, Attractors.

• **Linear Systems:** Solutions; Stability of autonomous systems, Geometrical analysis; BIBO stability, connection with frequency domain analysis.

• **Nonlinear Systems:** Solutions; Examples. Large-scale notions of stability (Lyapunov functions). Small-scale notions of stability (Linearization; stability and basin of attraction of an equilibrium point, stability of a periodic solutions and Floquet Multipliers). Graphical methods for the analysis of low-dimensional systems; Introduction to structural stability, Bifurcation theory. Introduction to chaotic systems.

Keywords

Dynamical Systems, Attractors, Equilibrium point, Limit Cycles, Stability, Lyapunov Functions, Bifurcations.

Learning Prerequisites

Required courses

• Linear algebra (MATH 111 or equivalent).

• Analysis I, II, III (MATH 101, 106, 203 or equivalent).

Recommended courses

• A BS-level Circuits & Systems class (EE204/205 or equivalent) or a Systems & Signals class (MICRO310/311 or equivalent) is strongly recommended.

• A first-year Probabilty class is useful (such as MATH-232, MATH-231, MATH-234(b), MATH-234(c), or equivalent).

Important concepts to start the course

- Linear Algebra (vector spaces, matrix operations, including inversion and eigendecomposition).
- Calculus (linear ordinary differential equations; Fourier, Laplace and z-Transforms).
- Basic notions of topology.
- Basic notions of probability.

Learning Outcomes

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

- Analyze a linear or nonlinear dynamical system.
- Anticipate the asymptotic behavior of a dynamical system.
- Assess / Evaluate the stability of a dynamical system.
- Identify the type of solutions of a dynamical sytem.

Teaching methods

- Lectures (blackboard), 2h per week
- Exercise session, 1h per week.

Expected student activities

Exercises in class/at home:

- Paper and pencil problems (80%)
- Matlab (20%)

Assessment methods

1. Mid-term 20%
2. Final exam 80%

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

Course notes; textbooks given as reference on the moodle page of the course.

Notes/Handbook

Course notes, exercises and solutions provided on the moodle page of the course.

Websites

- http://moodle.epfl.ch/course/view.php?id=303

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=303

Prerequisite for

Any class using dynamical systems.