INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

# MATHEMATICS FIELD_9 ECTS

# Introducing

## Description

## Évaluation

L'évaluation des acquis d'apprentissage est réalisée en continu tout le long du semestre. En fonction des enseignements, elle peut prendre différentes formes : examen écrit, oral, compte-rendu, rapport écrit, évaluation par les pairs...

# Practical info

## Location(s)

Toulouse

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# Dynamical systems

## Introducing

## Description

- Definition of an autonomous ODE, definition of a Cauchy Problem, Theorem of Cauchy-Lipschitz
- Definition of a maximal solution and the maximum domain, analysis of the stability
- Qualitative properties: conservative systems, Lyapunov functions, introduction to bifurcations (+ limit cycles)
- Construction of the phase portrait of an ODE in dimension 1 and 2
- Numerical integration of an autonomous ODE (Euler, RK, Crank-Nicholson)
- Analysis of a numerical scheme: stability, consistency and convergence

The above-mentioned concepts will be introduced and applied to 4 dynamical systems used all along this class

## Objectives

At the end of this module, the student will have understood and be able to

-Define a Cauchy problem and prove the well-posedness of an autonomous ordinary differential equation
-Obtain qualitative properties of the solution of an autonomous ordinary differential equation (maximal solution, maximum domain, stability)
-Draw the phase portrait of an autonomous ordinary differential equation in dimension 1 and 2
-Solve using numerical integration an autonomous ordinary differential equation
- Apply these notions to analyze a dynamical system used in physics, biology or population dynamics

## Necessary prerequisites

Differential and integral calculus, linear algebra

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# Complements of probabilities

# Introducing

## Description

Program (detailed contents):
- Sigma-algebra, sigma-algebra generated by one or many random variables.
- Conditional expectation with respect to a sigma-algebra generated by a partition and then with respect to a general sigma-algebra. Main properties of conditional expectation.
- Gaussian random vectors. Main properties, Gaussian miracle for the independence of coordinates, projection theorem for Gaussian random vectors, multidimensional central limit theorem.
- Classical inequalities arising in probability theory: Markov, Chebyshev, Cauchy-Schwarz and Hölder.
- Modes of convergence of random variables: almost sure, in probability, in distribution, in the Lp spaces, and links between them.

## Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):
- The notion of sigma-algebra generated by one or many random variables.
- The definition and main properties of a conditional expectation.
-The definition and main properties of a Gaussian vector.
-The various modes of convergence in probability theory and the links between them.

The student will be able to:
- Compute a conditional expectation with respect to a given sigma-algebra.
- Prove that a random vector is a Gaussian random vector and give the underlying parameters (expectation and covariance matrix); use the specific properties of Gaussian random vectors.
- Use classical inequalities appearing in probability theory.
- Prove that a given sequence of random variables converges (or not) almost surely, in probability, in distribution or in Lebesgue spaces (Lp spaces).

## Necessary prerequisites

Course on Probability and Statistics (2MIC Semester 4).

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# Ecological Transition, GHG Reduction, Responsibility and Environment (EARTH)

# Introducing

## Description

The teaching includes a "2 tonnes" workshop, which provides a fun way of understanding the orders of magnitude linked to the objectives of carbon neutrality in 2050. It also includes assignments on the following topics: housing; electricity production; inequalities and responsibilities; mobility; the climate inaction debate; agriculture and food; and aeronautics. Students also work on a complex problem linked to ecological issues, starting their reflections from an everyday object or service.

## Objectives

At the end of this module, the student will be able to:

- Be comfortable with the fundamental concepts related to greenhouse gas emissions, and be able to make simple calculations on this subject.
- Know the order of magnitude of important quantities.
- Be able to fetch emission values from the ADEME database and use them appropriately.
- Think about ecological issues in all their complexity and study a specific problem
- Have an understanding of life cycle analysis and how to apply it
- Be able to research scientific literature
- Be able to understand and analyse figures/data
- Draw political conclusions from scientific facts and one's own values
- Debate, discuss and confront points of view.

## Necessary prerequisites

Basic knowledge on energy.

## Évaluation

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# Practical info

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