

## 23169 - Linear Algebra and Dynamic Systems

### Syllabus Information

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**Academic Course:** 2018/19

**Academic Center:** 304 - Faculty of Law and Economics  
332 - Faculty of Economic and Business Sciences

**Study:** 3327 - Bachelor's degree in International Business Economics

**Subject:** 23169 - Linear Algebra and Dynamic Systems

**Credits:** 5.0

**Course:** 3 and 4

**Teaching languages:**

Theory: Group 1: English

Seminar: Group 101: English

**Teachers:** Gabor Lugosi

**Teaching Period:** Second Quarter

### Presentation

This course is dedicated to the principles of dynamical systems. The material includes examples of growth models and their analysis via systems of differential equations. Basic notions such as equilibrium, stability, bifurcations, sources, sinks, etc. are discussed. Linear systems of differential equations are thoroughly analysed and some aspects of nonlinear systems are discussed as well. The course also covers basic mathematical tools including principles of linear algebra, eigenvalues and eigenvectors of matrices, and complex numbers.

### Associated skills

The understanding of the dynamical systems treated in this course needs tools of linear algebra and complex numbers. These are necessary skills that students will learn during the course, and since they have many other applications, they will also be useful for them in the future. Moreover, the understanding of a mathematical theory and solving quantitative problems is also very helpful to exercise a logic thinking that can be applied when solving problems in any field.

### Learning outcomes

After following this course, the students should be able to read and understand a rigorous mathematic exposition in the field of linear algebra and dynamical systems. Understand the elements that form a dynamical system, the methods in order to solve it exactly or numerically and the basic properties that characterize it. The students should also be able to identify the characteristics of the models in dynamical systems that have applications to economy and administration.

### Prerequisites

This elective course is part of the 'Advanced Quantitative Methods' program (MQA), which are high demanding courses with strong quantitative content, so the prerequisite to follow this course is to have a good background in Mathematics. For the students in Garu d'Economia this means to have passed and have a good understanding of the courses of Mathematics I, II and III.

### Contents

1. Examples of simple differential equations, logistic growth model, equilibrium, stability.
2. Planar systems: linear systems of two differential equilibrium and their classification. Sources, sinks, saddle points.
3. Complex numbers. Complex eigenvalues and eigenvectors.
4. Higher-dimensional linear algebra: linear independence, quadratic matrices, determinants, eigenvalues, eigenvectors.
5. Higher-dimensional linear systems. Canonical forms.
6. The exponential function of a matrix. Autonomous and non-autonomous linear systems.

7. Non-linear systems. The variational equation and stability.

### **Teaching Methods**

In class there will be 20 lectures and 6 seminars. The lectures are selfcontained and explained in the blackboard, and essentially follow Chapters 1-8 of the book mentioned in the Bibliography. Before each seminar a list of exercises will be distributed. The students do the exercises at home individually or in groups of 2 or 3 students and they are graded. This is the continuous assessment of this course and corresponds to 20% of the final grade. The exercises are then corrected and commented during the seminars.

### **Evaluation**

The final grade is computed as: 20%: continuous assessment explained in Teaching Methods, 80%: Final exam.

Students whose final global grade is less strictly than 5, took the final exam, and did the continuous assessment (which means handling all the exercises) there will be a recuperation exam during the second term that will count as 80% as well. The grade of the continuous assessment cannot be modified.

### **Bibliography and information resources**

#### **Basic bibliography**

Large part of the material of the course is based on the book Hirsch, Smale, and Devaney: "Differential equations, dynamical systems, & an introduction to chaos"

#### **Teaching resources**

Other resources for the course, such as examples and plots will be posted in aula global