

# Systems Dynamics

Course ID: 267MI – Fall 2021

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**267MI –Fall 2021**

**Course Overview**

## Lecturers & examiners

- Thomas Parisini  
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(fenu@units.it)

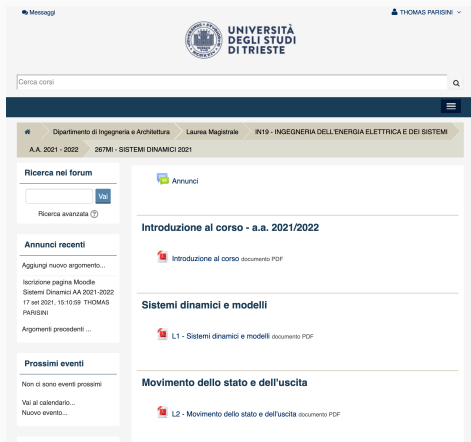
## Course home page

- slides, exercises and computer code examples
- old exams

<https://moodle2.units.it>

## Course credits

- 9 CFU



The screenshot shows the Moodle course interface for 'SISTEMI DINAMICI 2021'. At the top, there is a search bar with the text 'Cerca corsi' and a search icon. Below the search bar, the course breadcrumb is displayed: 'Dipartimento di Ingegneria e Architettura > Laurea Magistrale > IN19 - INGEGNERIA DELL'ENERGIA ELETTRICA E DEI SISTEMI > A.A. 2021 - 2022 > 267MI - SISTEMI DINAMICI 2021'. The main content area is divided into several sections: 'Ricerca nel forum' with a search input and a 'Vai' button; 'Annunci recenti' with a link to 'Introduzione al corso - a.a. 2021/2022' and a PDF document; 'Sistemi dinamici e modelli' with a link to 'L1 - Sistemi dinamici e modelli documento PDF'; and 'Movimento dello stato e dell'uscita' with a link to 'L2 - Movimento dello stato e dell'uscita documento PDF'. The user's name 'THOMAS PARISINI' is visible in the top right corner.

- **Final exam:** a preliminary written examination followed by oral questions.
- The **final grade** depends on both the written part and the outcome of the oral discussion.
- Written examination and oral discussion usually usually take during the same exam session.

## Written examination

The exam paper consists of 3 – 4 essay questions:

- typical numerical application problems
- specific questions about theoretical aspects (theorems, properties, definitions) could be included

## Oral questions

Oral questions deal with any possible topic, discussed and analysed in the lectures.

- A short discussion about the written examination results generally also takes place

## Homework (not compulsory)

- Advanced engineering specific projects are offered during the course, characterised by challenges more difficult to address than the usual ones.
- The aim is to stimulate learning advanced concepts during the course also to help the learning exercise
- These projects are then evaluated upon request by the students.
- It's allowed to solve the projects in groups, up to 3 persons.
- Working on homework problems is **not compulsory**

## Homework & final grade

- Homework contributes to the final grade, with an increment of the score up to 2 points.
- The grading of the homework is **independent** from the grading of the examination
- **Homework expiration**: the increment of the final exam score, using the homework grade, is allowed during the current academic year (**for the academic year 2021/2022** until the end of the examination session in **February 2023**). When the exam sessions of the current academic year are over, the homework grade expires.

## Examination timetable

- 3 sessions in January–February
- 3 sessions in June–July
- 1 session in September

## How to sign up for examinations

- In order to participate to the exam session you must sign up/register for the exam **(compulsory)**
- To sign up, use the students university career management system **Esse3** to access to the on-line University Services.
- Please, **pay attention** to the dates of the registration periods and the examination periods!



## Prerequisites

- Linear algebra, calculus and complex analysis
- Course 034IN “Fundamentals of automatic control” (or equivalent for students enrolled from other universities/programs)
- Basic knowledge of probability and statistics is not mandatory, but highly helpful

## Course organization

- Lectures
- Exercise sessions

## **Students who pass the course should be able to:**

- carry out a complete and comprehensive analysis of the main properties of deterministic and stochastic discrete-time dynamic systems;
- design and implement parametric estimation and identification, and state estimation algorithms that use available data or data collected in real-time with reference to engineering application scenarios;
- . . .

### **Students who pass the course should be able to**

- evaluate, among several options, what's the best choice of parametric estimation and identification, and state estimation algorithms starting from requirements and considering technological constraints;
- describe in a clear and plain way the functionalities of a parametric estimation and identification, and state estimation algorithm in the context of discrete-time dynamic systems and with the correct use of technical terminology

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Lect.	Content
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- 1 Course overview. Generalities: systems and models (defs, props, problems). Sampling and discrete-time representation of linear continuous-time dynamic systems.
  - 2 Time-evolution of state and output of linear dynamic systems.
  - 3 Stability of discrete-time dynamic systems.
  - 4 Model identification from data.
  - 5 A glimpse on prob. theory, random vars and discrete-time stochastic processes.
  - 6 Definitions and properties of the estimation and prediction problems.
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<b>Lect.</b>	<b>Content</b>
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| 7  | Dynamic models of stationary discrete-time stochastic processes. |
| 8  | Least-squares estimation.  |
| 9  | Bayes estimation.  |
| 10 | Solution of the prediction problem.                              |
| 11 | Identification Based on Prediction Error Minimization (PEM).     |
| 12 | Batch PEM Identification Algorithms.                             |
| 13 | State estimation from observed data.                             |
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## References on dynamic systems analysis:

P. J. Antsaklis and A. N. Michel.

***Linear Systems.***

Birkhäuser, 2006.

G. Calafiore.

***Elementi di Automatica.***

CLUT, Torino, 2007.

(in Italian).

G. Marro.

***Teoria dei Sistemi e del Controllo.***

Zanichelli, 1989.

(in Italian).

S. Rinaldi.

***Teoria dei Sistemi.***

CLUP, Milano, 1977.

(in Italian).

References on data-based estimation and identification:

T. Söderström. P. Stoica.

**System Identification.**

Prentice Hall, 1989.

L. Ljung.

**System Identification – Theory for the User.**

Prentice Hall, 1999.

S. Bittanti.

**Teoria della predizione e del filtraggio.**

Pitagora Editrice, Bologna, 2000.

(in Italian).

S. Bittanti.

**Identificazione dei Modelli e Controllo Adattativo.**

Pitagora Editrice, Bologna, 1997.

(in Italian).

S. Bittanti, M. Campi.

**Raccolta di Problemi di Identificazione, Filtraggio, Controllo Predittivo.**

Pitagora Editrice, Bologna, 1996.

(in Italian).

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**Course Overview**

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