# Systems Dynamics

## Course ID: 267MI – Fall 2020

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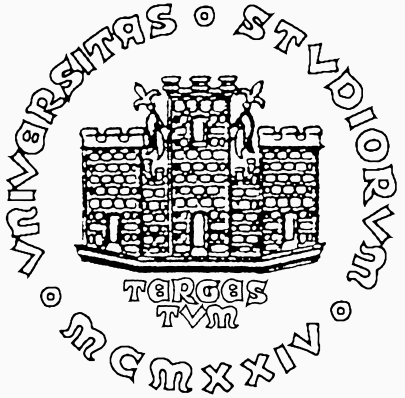


# 267MI –Fall 2020

# Course Overview

# Course Administration

## Lecturers & examiners

- Thomas Parisini (t.parisini@gmail.com)
- Gianfranco Fenu (fenu@units.it)

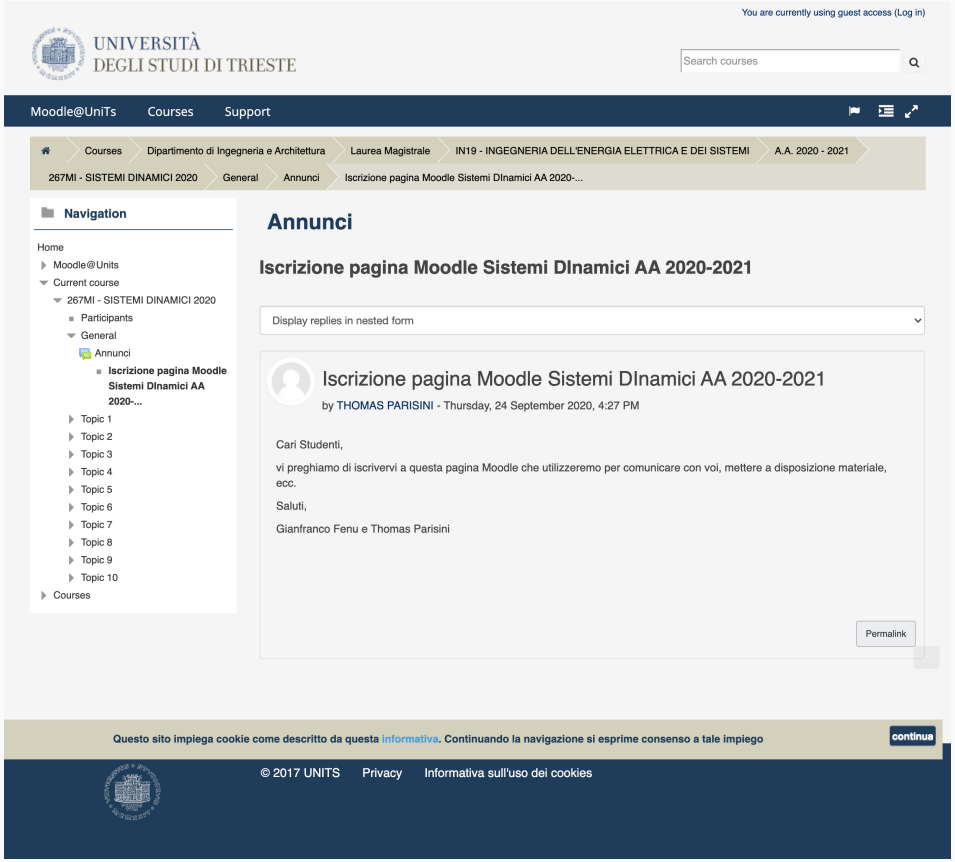
## Course home page

- slides, exercises and computer code examples
- old exams

https://moodle2.units.it

## Course credits

- 9 CFU



# Examination

- **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.

# Examination (cont.)

## 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

# Examination (cont.)

## 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**

# Examination (cont.)

## 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

# Exam Sessions

## 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!

# Course Information

## 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

# Desiderata

**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;
- . . .

# Desiderata (cont.)

**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

# Lectures Plan

| Lect. | Content |
|---|---|
| 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. |
| | ... |

# Lectures Plan (cont.)

| Lect. | Content |
|---|---|
| 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. |

# References

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 (cont.)

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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