



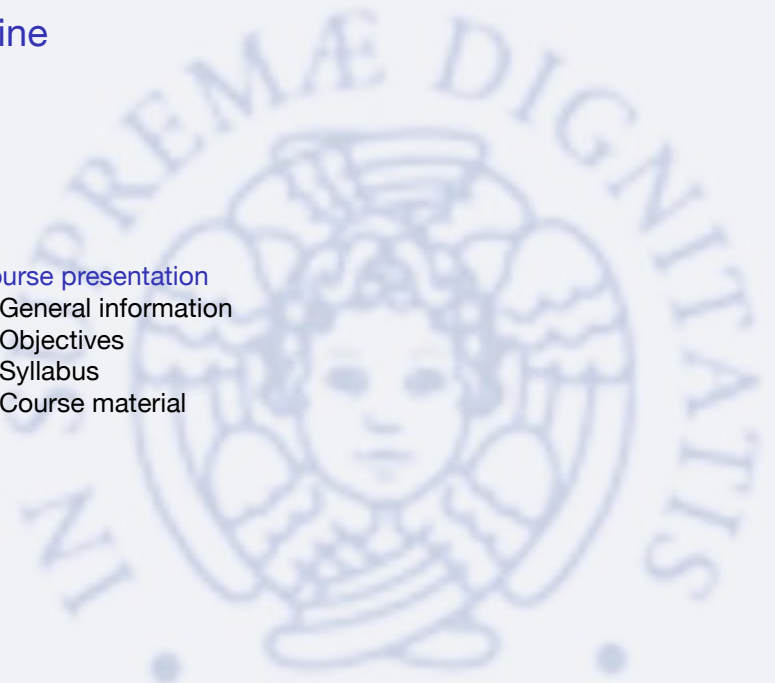
Introduction to “Process Dynamics and Control”

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First Year course, MS in Energy Engineering
University of Pisa, Academic Year 2018-2019

Outline

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- The background of the slide features a large, light blue watermark of the University of Pisa logo. The logo is circular and contains a central figure of a woman, likely the personification of Justice or Liberty, holding a scale and a sword. The Latin motto "IN SUPREMAE DIGNITATIS" is inscribed around the perimeter of the circle.
- 1 Course presentation
 - General information
 - Objectives
 - Syllabus
 - Course material

Course teachers

Prof. Gabriele Pannocchia

- Department of Civil and Industrial Engineering (Chemical Engineering)
- Office: @2nd floor (1 floor down main entrance), room 201
- Phone: 050 2217 838
- Email: gabriele.pannocchia@unipi.it
- Web Site: https://people.unipi.it/gabriele_pannocchia/

Objectives of the course

- 1 Understand the basics of process **control system** architectures
- 2 Understand the **dynamics** of process systems and how to model them
- 3 Understand the fundamentals of **controller design** for process systems
- 4 Understand the basics of **advanced process control and optimization**

Part I: Introduction and Dynamics

- 1 Introduction to Process Dynamics and Control (7 hours)
 - 1 Course presentation
 - 2 Process control systems: objectives, generalities, examples
 - 3 Elements of a process control system (measurement devices, standard controllers, actuators)
- 2 Dynamics of continuous time systems (22 hours)
 - 1 Physical models described by nonlinear differential equations
 - 2 Linear differential equations (n -th order and 1-st order)
 - 3 Example of dynamics of process systems
 - 4 Laplace Transform and Transfer Function (TF)
 - 5 Block diagrams
 - 6 State-Space Linear (SS) systems

Part II: Analysis

- 1 Stability analysis (6 hours)
 - 1 Stability definitions
 - 2 Routh criterion
 - 3 Root Locus
 - 4 Effects of poles and zeros
 - 5 Effects of controller elements (proportional, integral, derivative)
 - 6 Marginal stability
- 2 Frequency Analysis (7 hours)
 - 1 System response to a sinusoidal signal
 - 2 AR and phase of a linear systems
 - 3 Bode and Nyquist diagrams
 - 4 Stability criteria
 - 5 Comparison of Root Locus and Frequency Analysis

Part III: Design

3 Controller design (11 hours)

- 1 Sensibility and Complementary Sensibility function
- 2 Control performance (time and frequency) specifications
- 3 Controller analytical design and Internal Model Control (IMC)
- 4 PID tuning
- 5 Effect of uncertainties
- 6 More complex control systems: cascade, feedforward, split-range, selective, etc

4 Optimization and advanced control systems (7 hours)

- 1 An introduction to numerical optimization
- 2 Model Predictive Control systems
- 3 Applications to energy systems

Course material

Recommended books

- B. A. Ogunnaike, W. H. Ray. Process Dynamics, Modeling, and Control. *Oxford University Press*, 1994.
- G. Stephanopoulos. Chemical Process Control: An Introduction to Theory and Practice. *Prentice Hall International*, 1985.
- J. P. Hespanha. Linear Systems Theory. *Princeton University Press*, 2009.

Specific material - what?

- 1 Lecture slides
- 2 Class exercises and Matlab scripts

Specific material - Where? ... available at the Elearning site:

<http://elearn.ing.unipi.it/course/view.php?id=1219>

- Registration to the course at the Elearning site is mandatory!

Student office hours and list

Student office hours

- GP will be available for questions and clarifications on **Friday** 14:30-16:30
- Presence must be **confirmed** by email at `gabriele.pannocchia@unipi.it`
- **Quick questions** can also be asked **by email**

Student list

- Each student must be **enrolled in the course** at the E-learning site
- All communications will be sent **via email from E-learning** (make sure your address at E-learning is up to date)

Examination scheme

- Step 0 - Home exercises (Matlab) assigned during the course
- Step 1 (80%) - Written exam (Theory and exercises) - Admission to Step 2 with 18/30
- Step 2 (20%) - Quick oral discussion on exercises