Course guide
295553 - 295EQ021 - Process Control

Last modified: 14/06/2023

Unit in charge: Barcelona East School of Engineering
Teaching unit: 707 - ESAII - Department of Automatic Control.

Degree: MASTER'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2019). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: JORDI SOLÀ SOLER

Others:

PRIOR SKILLS

Basic mathematical knowledge (linear algebra, elementary calculus, complex variable and linear differential equations) and basic control knowledge.

Basic knowledge of process simulation (steady state) and the use of commercial packages for process simulation (AspenHYSYS, ChemCAD, UniSim, VMGSim, etc.).

REQUIREMENTS

None

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMUEQ-03. Conceptualize engineering models, apply innovative methods in the resolution of problems and adequate computer applications, for the design, simulation, optimization and control of processes and systems
CEMUEQ-04. Ability to solve problems that are unfamiliar, ill-defined, and have opposed specifications, considering the possible solution methods, including the most innovative, selecting the most appropriate, and being able to correct the implementation, evaluating the different design solutions

Generical:
CGMUEQ-11. To have the skills of autonomous learning to maintain and improve the competencies of chemical engineering that allow the continuous development of the profession

Transversal:
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

TEACHING METHODOLOGY

The lessons are organised in theoretical sessions, problem sessions and practical sessions. Theoretical sessions include the explanation of the theoretical concepts and the presentation of examples. Problem sessions include the resolution of exercises and problems. The teacher will induce the students to actively participate during the session. Practical sessions consist in the development of different practical works at the laboratory, with the support of informatic programs specially oriented to the analysis and design of control systems.

LEARNING OBJECTIVES OF THE SUBJECT

By the end of the course, students should be able to:

• Analise and design a control system for a continuous chemical process.
• Simulate and asses the performance of a continuous chemical process including its control system.

In order to achieve these general learning outcomes, a set of specific objectives are established. Thus, by the end of the course, students should be able to:

• Produce a dynamic simulation of a continuous chemical process using general and specific software
• Assess the stability and controllability of a process.
• Propose simple and advanced control structures for a given chemical process.
• Implement the simulation of the process and its control system using the appropriate software tool.
• Identify the set of sensors and actuators required to implement a control system for a chemical process.
• Tune the parameters of the elements of the control system.
• Improve and eventually optimize the control system.

STUDY LOAD

Type	Hours	Percentage
Hours large group	34,0	22.67
Hours small group	20,0	13.33
Self study	96,0	64.00

Total learning time: 150 h

CONTENTS

Linear systems modelling

Description:
Basic theory of linear system modelling and identification in time and frequency domains. Presentation of examples and problems in the field of chemical processes.

Specific objectives:
- Linear system modelling: linearization, transfer function, block diagrams, state space representation
- Time response of first and second order systems
- Frequency domain analysis. Bode and Nyquist diagrams
- Stability and controllability
- System identification

Related activities:
Two practical session in the lab dedicated to the system analysis and modelling, and process simulation

Full-or-part-time: 43h 30m
Theory classes: 12h
Laboratory classes: 4h
Self study : 27h 30m

Controller analysis and design

Description:
Present the main techniques of feedback controller analysis and design in time and frequency domains, with application to the control of chemical processes.

Specific objectives:
- Basic control actions (P, I, D)
- Standard and modified PID configurations
- Experimental PID tuning methods
- Algebraic PID design
- Frequency compensators

Related activities:
A practical session devoted to the use of MATLAB for the analysis and design of controllers.

Full-or-part-time: 28h
Theory classes: 8h
Laboratory classes: 2h
Self study : 18h

Advanced controllers

Description:
Overview of the main advanced control techniques and assessment of their suitability in different types of chemical processes.

Specific objectives:
- Modifications on the basic PID
- Advanced PID concepts
- Feedforward, cascade, split-range and ratio control
- Digital control systems

Related activities:
A practical session devoted to the use of MATLAB for advanced controller analysis and design.

Full-or-part-time: 28h
Theory classes: 8h
Laboratory classes: 2h
Self study : 18h

Multivariate control

Description:
Generalisation of the transfer function concept for systems with multiple inputs and outputs. Introduction of controller analysis and design tools for this type of systems.

Specific objectives:
- External description of multivariate systems
- Analytical tools for multivariate systems
- Controller design tool for multivariate systems

Related activities:
A practical session will be dedicated to the use of MATLAB for the analysis of multivariate control systems.

Full-or-part-time: 16h
Theory classes: 4h
Laboratory classes: 2h
Self study : 10h

Chemical process control

Description:
To examine the common loops encountered in chemical process control: loop characteristics, type of controller to use, its response, tuning, and limitations.

Specific objectives:
- Degrees of freedom
- Flow control
- Liquid level and pressure control
- Gas pressure control
- Temperature control
- Pump and compressor control
- Boiler control
- Distillation control
- Plantwide control and optimization

Related activities:
Half lab session devoted to the analysis and design of different control loops for chemical processes

Full-or-part-time: 20h 30m
Theory classes: 6h
Laboratory classes: 1h
Self study : 13h 30m

Control instrumentation in chemical processes

Description:
Study of the specific control systems instrumentation for the chemical industry.

Specific objectives:
- Standard process and instrumentation diagrams (P&ID)
- Signal acquisition chain
- Sensors and actuators selection and sizing
- Components maintenance

Related activities:
Half lab session devoted to the study of instrumentation systems for chemical processes

Full-or-part-time: 14h
Theory classes: 4h
Laboratory classes: 1h
Self study : 9h

GRADING SYSTEM

The final mark is calculated through four assessments: two partial exams, the assessment of the practical works and the mark of classroom exercises, according to the following weights:
Applied exercises 10%
Laboratory marks 20%
First partial exam (P1) 35%
Second partial exam (P2) 35%

There will be a re-assessment exam for those students who don't pass the subject and meet the necessary requirements according to point 1.1.3. of "Normativa d'Avaluació i Permanència en els estudis de grau i màster de l'EEBE (https://eebe.upc.edu/ca/estudis/normatives-academiques/documents/eebe-normativa-avaluacio-i-permanencia-18-19-aprovat-je-2018-06-13.pdf)".

EXAMINATION RULES.

To do the exams, students can have one sheet of notes (two pages DIN A4), the s and z transform tables, and a calculator.

BIBLIOGRAPHY

Basic:

- Angulo Bahón, Cecilio; Raya Giner, Cristóbal. Tecnología de sistemas de control [on line]. Barcelona: Edicions UPC, 2004 [Consultation: 13/05/2020]. Available on: http://hdl.handle.net/2099.3/36817. ISBN 9788498802931.
- Åström, Karl J; Hägglund, Tore. Control PID avanzado. Madrid [etc.]: Pearson Educación, cop. 2009. ISBN 9788483225110.
- Seborg, Dale E. Process dynamics and control. 4th ed. Hoboken, NJ: Wiley, [2017]. ISBN 9781119285915.
- Kuo, Benjamin C. Digital control systems. 2nd ed. New York ; Oxford: Oxford University Press, cop. 1992. ISBN 0195120647.
- Svrcek, William; Mahoney, Donald P.; Young, Brent R. A real-time approach to process control [on line]. 2nd ed. Chichester [etc.]: John Willey & Sons, [2014] [Consultation: 13/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=4037756. ISBN 9781119993872.
- Stephanopoulos, George. Chemical process control : an introduction to theory and practice. Wilmington, [etc.]: Prentice-Hall, 1984. ISBN 0131285963.

Complementary:

- Ogata, Katsuhiko. Ingeniería de control moderna [on line]. 5a ed. Madrid [etc.]: Pearson Educación, cop. 2010 [Consultation: 13/05/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=1259. ISBN 9788483229552.
- Coughanowr, Donald R. Process systems analysis and control. 3rd ed. New York [etc.]: McGraw-Hill, cop. 2009. ISBN 9780073397894.
- Skogestad, Sigurd; Postlethwaite, Ian. Multivariable feedback control : analysis and design. 2nd ed. Chichester [etc.]: John Wiley & sons, cop. 2005. ISBN 9780470011683.
- Costa Castelló, Ramon; Fossas Colet, Enric. Sistemes de control en temps discret [on line]. Barcelona: Universitat Politècnica de Catalunya. Iniciativa Digital Politècnica, 2014 [Consultation: 13/05/2020]. Available on: http://hdl.handle.net/2099.3/36857. ISBN 9788498804638.
- Ollero de Castro, Pedro; Fernández Camacho, Eduardo. Control e instrumentación de procesos químicos. Madrid: Síntesis, DL 1997. ISBN 8477385173.
- Luyben, William L. Process modeling, simulation, and control for chemical engineers. 2nd ed. New York, [etc.]: McGraw-Hill, cop. 1990. ISBN 0071007938.