Universitat Autònoma de Barcelona

2022/2023

Control, Instrumentation and Automatisms

Code: 102445
ECTS Credits: 6

Degree	Type	Year	Semester
2500897 Chemical Engineering	OB	3	1
2500897 Chemical Engineering	OB	3	2

Contact

Name: Juan Antonio Baeza Labat
Email: juanantonio.baeza@uab.cat

Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Teachers

Albert Guisasola Canudas

Prerequisites

Non steady-state mass and energy balances.
Ordinary differential equations.
Complex variable calculus
Willingness to understand the main concepts of process control.

Objectives and Contextualisation

To learn about automatic control as an essential tool in the chemical industry to guarantee its operation and the stability of the production processes.
Know the basic tools for process control and instrumentation in chemical engineering systems.
Identify the elements needed to implement a feedback control loop.
Describe the dynamics of common systems in chemical engineering using models developed from balances and expressed in the Laplace space.
Design control loops and know the procedures to determine their stability and tuning controllers.
Know the frequency response methods for the design and study of control loops.
Identify the elements needed to design other more advanced control schemes.
Use of simulation software for control design.

Competences

Chemical Engineering

- Demonstrate basic knowledge of the use and programming of computers, and apply the applicable IT resources to chemical engineering.
- Demonstrate knowledge of the different reaction, separation and processing operations for materials, and transport and circulation of fluids involved in the industrial processes of chemical engineering.
- Demonstrate understanding of the main concepts for controlling chemical engineering processes.

- Develop personal work habits.
- Develop thinking habits.
- Work in a team.

Learning Outcomes

1. Apply IT resources to the simulation and control of processes.
2. Apply knowledge of separation operations and reactors to the preparation of models and to the simulation of processes.
3. Develop a capacity for analysis, synthesis and prospection.
4. Develop critical thinking and reasoning
5. Use mathematical models of dynamic systems and processes in the field of chemical engineering.
6. Work autonomously.
7. Work cooperatively.

Content

Theme 0: Laplace Transforms (LT)
LT of basic functions.
Solution of differential equations with LT.
LT inversion.

Theme 1: Introduction to process control
1.1.- Control Systems.
1.2.- Definitions and basic concepts. Control schemes.
1.3.- Modelling of the dynamic behaviour of chemical processes. Input-output models.

Theme 2: Analysis of the dynamics of chemical processes
2.1.- Transfer function (TF) of a process with only one output.
2.2.- TF of a process with multiple outputs.
2.3.- TF poles and zeros.
2.4.- First-order systems.
2.5.- Second-order systems.

Theme 3: Feedback control
3.1.- Concept of feedback control. Instrumentation: sensors and final elements. Selection of control valves.
3.2.- Closed loop dynamics. Effect of the different control actions.
3.3.- Stability. Routh-Hurwitz criterion.
3.4.- Design and tuning of controllers.
3.5.- Specification sheets for control loops.

Theme 4: Design based on frequency response
4.1.- Frequency response analysis. Bode and Nyquist diagrams.
4.2.- Design of feedback controllers using frequency response techniques.

Theme 5: Other control configurations
5.1.- Cascade control.
5.2.- Feedforward control.
5.3.- Other control schemes.
5.4.- Systems with interactive units.
5.5.- Typical control schemes in the chemical industry.

Methodology

Theory classes. Basic theoretical concepts are introduced in an orderly and concise way for further practical development. Small activities are proposed to be developed by the student during the class.

Classes of problems. A series of problems is selected from the collection of each topic. The step-by-step resolution is shown for the most representative problems and the scheme for solving other problems is presented. Problem solving by students.
Seminars / Works: Instrumentation, Introduction to Simulink, PLC Programming, Simulink: Closed Loop Dynamics, Simulink: Frequency Response.
Moodle will be used as the virtual platform to communicate with students.
Simulink tutorials at YouTube: https://www.youtube.com/channel/UCq4HnZPBPb4A3JspPish78g

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Seminars	5	0.2	1, 3, 4
Theory theme 0. Laplace transforms	2	0.08	5
Theory theme 1. Introduction	2	0.08	3
Theory theme 2. Analysis of chemical processes dynamics	4	0.16	2, 5
Theory theme 3. Feedback control	12	0.48	2, 5
Theory theme 4. Design based on frequency response	4	0.16	4
Theory theme 5. Other control configurations	4	0.16	2, 5
Type: Supervised			
Theme 0 problems	2	0.08	5
Theme 2 problems	2	0.08	3
Theme 3 problems	8	0.32	3
Theme 4 problems	2	0.08	3
Type: Autonomous			
Accomplishment of works.	7	0.28	1
Individual or small group tutorials	5	0.2	1, 3, 4
Problem solving	50	2	1, 3, 4
Study of theoretical background	33	1.32	3, 4

Assessment

(a) Scheduled evaluation process and activities

The following are the activities of evaluation of the subject with its percentage of weight on the final grade:

- Activity 1 (4%). Practice. Introduction to Simulink.

- Activity 2 (3%). Instrumentation and control seminar(s).
- Activity 3 (4%). Practice. Programmable logic controller(PLC).
- Activity 4 (7%). Work. Simulink closed loop.
- Activity 5 (7%). Work. Simulink frequency response.
- Activity 6 (25%). Partial exam 1 - Dynamics of chemical processes.
- Activity 7 (25%). Partial exam 2 - Closed loop dynamics.
- Activity 8 (25%). Partial exam 3 - Frequency response.

Each partial exam has a duration around 2.5 hours and consists of a theory part (1/3 grade, 0.5 hours) and a problem (2/3 grade, 1.5 hours).

In order to be able to apply the calculation of the final grade, it is required:
- a minimum average of 4.0 of the theory of partial examinations.
- an average score of partial exams higher than 4.5.

If either of the two criteria is not met, the maximum final grade for the subject will be 4.0.

The non-presence in class when evaluation tests are carried out is a zero of the activity, without possibility of make-up.

b) Programming of evaluation activities

The schedule of evaluation activities will be given on the first day of the course and will be made public through the Moodle. The following schedule is foreseen:

- Activity 1. Week 4
- Activity 2. Week 7
- Activity 3. Week 8
- Activity 4. Week 9
- Activity 5. Week 13
- Activity 6. Week 7
- Activity 7. Week 12
- Activity 8. Week 16

(c) Recovery process

Students may apply for make-up as long as they have submitted to a set of activities that represent at least two-thirds of the total grade for the subject. Of these, those students who have a grade ofmore than 3 on average for all subject activities may be subject to make-up.

The make-up exam will include all the contents of the subject. This exam will consist of a theory part (1/3 exam grade) and two problems (2/3 exam grade). The mark of this exam will replace the mark of the activities 6-8 (partial exams). A minimum of 4.0 in the theory part and a minimum of 4.5 in the exam will be required to apply this calculation. If either of the two criteria is not met, the maximum final grade for the subject will be 4.0.

According to the coordination of the Grade and the direction of the School of Engineering the following activities cannot be recovered:
- Activity 1 (4%).
- Activity 2 (3%).
- Activity 3 (4%).
- Activity 4 (7%).
- Activity 5 (7%).
- Evaluative activities of any type in which the student has committed an irregularity (copy, plagiarize, let copy ...).

d) Grade review procedure

For each assessment activity, a place, date and time of review will be indicated where the student can review the activity with the professor. In this context, complaints can be made about the grade of the activity, which will be evaluated by the professor responsible for the subject. If the student does not submit to this review, this activity will not be reviewed at a later date.

e) Qualifications

Honor plates. Awarding an honor roll grade (MH) is the decision of the faculty responsible for the subject. UAB regulations state that MH can only be awarded to students who have obtained a final grade of 9.00 or more. Up to 5% of the total number of students enrolled may be awarded.

A student will be considered non-assessable (NA) if he has not presented to a set of activities the weight of whichequals a minimum of two thirds ofthe total grade of the subject.

f) Student Irregularities, Copying and Plagiarism

Without prejudice to other disciplinary measuresthat may be deemed appropriate, irregularities committed by the student that may lead to a variation in the grade of an evaluation act shall be graded with a zero. Therefore, copying, plagiarism, cheating, letting copy, etc. in any of the evaluation activities will involve suspending with a zero. Evaluation activities graded in this way and by this procedure will not be recoverable.

h) Evaluation of Repeating Students

The only change in the assessment of the subject repeaters is the possibility of maintaining the grades of the 1-5 activities taken to the previous course. This option must be communicated by email to the professor responsible, no later than 15 days after the start of classes.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Partial exam 1. Dynamics of chemical processes.	25%	2	0.08	2, 3, 4, 6, 5
Partial exam 2. Closed-loop dynamics. Tuning.	25%	2	0.08	2, 3, 4, 6, 5
Partial exam 3. Frequency response. Other control schemes.	25%	2	0.08	2, 3, 4, 6, 5
Simulink work and other activities	25%	2	0.08	1, 3, 4, 7, 6, 5

Bibliography

Most relevant bibliography
Stephanopoulos, G."Chemical Process Control: An Introduction to Theory and Practice". Prentice-Hall (New Jersey), 1984.
Seborg, D.E.; Edgar, T.; Mellichamp, D.A. "Process Dynamics and Control". J. Wiley (NY), 2nd edition. 2004.
Babatunde A. Ogunnaike, W. Harmon Ray. "Process Dynamics, Modeling and Control". Oxford University Press. 1994.

Additional references
Ollero de Castro, P. ; Fernández, E. "Control e instrumentación de procesos químicos". Síntesis (Madrid), 1998.
Baeza, J.A. Book chapter: "Principles of Bioprocess Control" al llibre "Current Developments in Biotechnology and Bioengineering. Bioprocesses, Bioreactors and Controls", Elsevier, 2017.
http://www.sciencedirect.com/science/article/pii/B9780444636638000185

Software

Matlab - Simulink