COURSE DATA

Data Subject	
Code	34762
Name	Process dynamics and control
Cycle	Grade
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
1401 - Degree in Chemical Engineering	School of Engineering	3	Second term

Subject-matter

Degree	Subject-matter	Character
1401 - Degree in Chemical Engineering	10 - Dynamics and control	Obligatory

Coordination

Name	Department
LOPEZ MARTINEZ, JAVIER	245 - Chemical Engineering
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SUMMARY

Automatic control has played a vital role in the advancement of engineering and science, becoming an important and integral part of modern industrial manufacturing processes. The chemical process control is a specialty of Automatic that deals the selection and application of techniques for safe and efficient operation of process plants. As advances in theory and practice of automatic control means to provide optimal operation of dynamic systems, improve quality and lower production costs, expand production rates, free from the complexity of many routine, repetitive tasks , etc.., most engineers and scientists must have good knowledge in this field.

The aim of Dynamics and Control subject is to enable the student for the analysis and design of control systems. It deals with the problems of process modeling and feedback control, graphical methods to represent feedback systems (block or flow diagrams), methods to analyze their stability, and finally the usual methods of design controllers / compensators. The course contents are: modeling of continuous systems. Transfer function and frequency response. Representation of feedback systems. Methods of analysis of the stability of feedback systems. Controller design methods, which are divided into thematic

units listed below. It is a compulsory subject that is taught quarterly in the second semester of the third year of Degree in Chemical Engineering. The curriculum consists of a total of 6 ECTS. This is a subject with a practical component in which, following the introduction of the concepts, students will undertake numerous practical exercises and experimentation in the laboratory.

The overall objectives of the course are:

- To educate the student of the importance of discipline and control dynamics in the safe and efficient operation of process plants.
- To inform the student of selection methods and application of techniques to achieve the optimal performance of dynamic systems, improve quality and lower costs of production and release of the complexity of many routine and repetitive tasks.
- To develop the students' capacity for analysis and design control systems.
- To develop the students’ ability for setting up and solving numerical problems of dynamics and control of processes, as well as to interpret the results.
- To enhance students' abilities in reasoning and systematic work.
- To encourage and promote in the student those values and attitudes that must be inherent to an engineer.

The **contents** of the subject are: Modelling of continuous systems. Transfer and frequency response. Representation of feedback systems. Analysis methods of the stability of feedback systems. Design methods of controllers.

Remarks: Theoretical classes will be taught in Spanish and the practical and laboratory classes according to the subject information available on the degree website.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

To successfully address the subject it is necessary that the student has previous knowledge and a required level for the subjects taken in first, second and third year (first semester) and in subjects studied simultaneously in the second semester of third year. Among such prior knowledge it is included:

Solving systems of differential equations.
The Laplace transform.
Conservation laws.
Balance property approach
Unit Operations, transport phenomena and chemical reaction engineering.

COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

1401 - Degree in Chemical Engineering

- G3 - Knowledge of basic and technological subjects that allows students to learn new methods and theories and provides them with versatility to adapt to new situations.
- G4 - Ability to solve problems with initiative, decision-making skills, creativity and critical reasoning and to communicate and transmit knowledge, abilities and skills in the field of industrial engineering.
- R6 - Knowledge of the fundamentals of automatic mechanisms and control methods.

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

Learning Outcomes:

- Select and apply appropriate mathematical methods to solve problems (G3, G4)
- To model the most common industrial processes in the industry (G3, G4).
- Understand and operate the block and flow diagrams to represent a feedback system (R6).
- Analyze whether a feedback system is stable or not, and if so, test its stability margins (R6).
- Know the different types of compensation that can be used (R6).
- Design the compensator control system according to transitional/ frequencial specifications (R6).

Skills to acquire:

The student should be able to:

- Distinguish lumped and distributed parameter systems.
- Model dynamic and static processes.
- Use the Laplace transform to solve differential equations.
- Determine the transfer function matrix of a process with multiple inputs and outputs.
- Identify and describe the standard input systems.
- Obtain the dynamic responses of open-loop linear systems.
- Apply linearization methods in nonlinear systems.
- Identify and reflect the transport delays mathematically.
- Transcribe physicochemical processes in block diagrams.
- Propose closed-loops of feedback control.
- Analyze the different elements of a control loop.
- Differentiate between different types of actions and feedback controllers.
- Differentiate and obtain the closed-loop transfer functions for servo and control systems.
- Obtain the transient responses of feedback-controlled processes.
- Determine the characteristic equation of a control system.
- Evaluate the stability of a system fromn the Routh's test and the method of root locus.
- Assess performance criteria for closed loop systems.
- Design feedback controllers by direct synthesis, internal model, Cohen-Coon methods and methods based on the integral of the error.
- Carry out the adjustment on the controller installation by trial and error and by the method of continuous variations.
- Determine the frequency response in linear systems.

- Obtain Bode Plots.
- Determine the stability of a system according to the Bode criterion.
- Designing controllers by gain and phase margin methods.
- Design controllers by the Ziegler-Nichols rules through the frequency response.
- Determine the stability of a system according to the Nyquist criterion.

- Use simulators to study the dynamic behavior of processes and the design of control systems.
- Perform process control experiments.
- Interpret and report experimental results.

In addition to the specific objectives mentioned above, during the course the development of several **social and technical skills** will be encouraged, among which the following are included:

- Ability to analyze and synthesize.
- Ability to communicate ideas, problems and solutions.
- Ability to argue from rational and logical criteria.
- Ability to communicate in a properly and organized manner.
- Ability to develop a problem in a systematic and organized way.
- Ability to critically analyze the results of a problem.
- Ability to work autonomously.
- Ability to integrate and participate actively in group tasks.
- Ability to properly distribute the time for development of tasks.

DESCRIPTION OF CONTENTS

1. INTRODUCTION. PROCESS CONTROL

Illustrative examples. Classification of control strategies. Process control and block diagrams. Control and modeling. Analog control vs. digital control. Economic justification of process control.

2. MODELLING THE STATIC AND DYNAMIC BEHAVIOR OF PROCESSES

Development of mathematical model. Mathematical modeling of some chemical processes. Lumped and distributed parameter systems. Dynamic of a heated stirred tank system, of an equilibrium-stage separation system and a heat exchange system.

3. OPEN-LOOP DYNAMICS OF LINEAR SYSTEM. THE TRANSFER FUNCTION

The Laplace transform. The transfer function. Transfer function matrix of a process with multiple inputs and outputs. Standard process inputs. Dynamic responses. First order systems. First-order systems in series. Interactive and noninteractive systems. Second-order systems. Linearization of nonlinear systems. Transport delay.

4. FEEDBACK CONTROL. CLOSED-LOOP SYSTEM

Feedback control. Analysis of the various elements of a control loop. Sensors and transmitters. Final control elements. Feedback controllers. Actions and types. Dynamics of feedback controlled processes. Closed-Loop transfer functions. Servo and control systems. Transient responses. Stability. The characteristic equation. Routh test. Diagram of root locus.

5. DESIGN OF FEEDBACK CONTROLLERS

Performance criteria of closed-loop systems. Direct synthesis method. Control through the internal model. Design relations for PID controllers. Cohen-Coon method. Methods based on the criterion of the error integral. Setting the controller on the installation. Controller setting by trial and error. Method of continuous oscillations (Ziegler-Nichols).

6. FREQUENCY RESPONSE OF LINEAR SYSTEMS

Frequency response. Substitution rules. Bode plots. Closed-loop response by the method of the frequency response.

7. DESIGN OF CONTROLLERS USING FREQUENCY RESPONSE THECNIQUES

Bode stability criterion. Gain and phase margins. Application to the design of controllers. Ziegler-Nichols rules through the frequency response. Nyquist stability criterion.

8. SEMINARS-DYNAMICS AND CONTROL ACTIVITIES

Simulation of the frequency test. Using computer-simulation packages in the area of Dynamics and Control.

9. DYNAMICS AND CONTROL LABORATORY

Control of an interactive system tanks. Temperature control of a heating block. Calculations and reporting.

WORKLOAD

ACTIVITY	Hours	% To be attended
Classroom practices	25,00	100
Theory classes	25,00	100
Laboratory practices	10,00	100
Development of group work	5,00	0
Study and independent work	25,00	0
Preparation of evaluation activities	15,00	0
Preparing lectures	15,00	0
Preparation of practical classes and problem	20,00	0
Resolution of case studies	10,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

The development of the course is structured around the theory and problems classes, seminars, laboratory sessions and the performance of tasks.

In the theory classes we will use the lecture model. The teacher will present and / or explain the contents of each issue stressing the key aspects for understanding (G3, R6).

Practical classes of problems will be developed following two models. In some classes the professor will resolve a number of sample problems so that the students learn to identify the essential elements of the approach and problem resolution. In other problems the students, individually or arranged in clusters, will be who should solve similar problems under the supervision of the teacher. After the work, the problems will be collected, analyzed and corrected by the teacher or the students themselves (G3, G4, R6).

In the seminar sessions students, individually or arranged in groups, will be instructed in the use of computer-simulation packages in the area of Dynamics and Control; they also must solve specific problems using these techniques (G3, G4, R6).

For practical laboratory sessions, where attendance is mandatory, students will have a practical guide and the experimentation will be conducted strictly by them under the teacher supervision (G3, G4, R6).

The proposed work for the students will be divided into three types: full Problems of similar complexity to those proposed in exams (G4, R6), questionnaires aimed at preparing the most important concepts of each topic and self-correcting tests, performed on the Virtual Classroom (G3, R6). Some of these activities will take place in class and the rest will have a timetable for completion and delivery by the students. After correction, students will be informed of their results and they will receive a summary of the most consolidated and frequent failures.

EVALUATION

Attendance to the laboratory of experimental practices is a **non-recoverable and obligatory** activity to overcome the subject.

The assessment of student learning will take place following two methods:

Method A: By assessing the activities of students (questionnaires and problems), the laboratory grade and objective exams.

To be evaluated by the Mode A, students must have attended 80% of classroom lessons and 100% of the lab classes. Likewise, students should also get in the activities proposed an average score equal to or greater than 4 (over 10). Once these requirements are achieved, the mark of this mode is obtained as the greater of:

- the weighting of the average mark of the objective exams (60%), the average mark of the laboratory (15%) and the average score of the activities (25%), provided that the average mark of the objective exams is equal to or greater than 4 (over 10).
- the weighting of the average mark of the objective exams (85%) and the average score of the laboratory (15%), provided that the average mark of the objective exams is equal to or greater than 5 (over 10).

Method B: By assessing the activities of students (questionnaires and problems), the laboratory grade and the final exam.

To be evaluated by the Mode B, the student must have attended 100% of the lab classes. Beyond this requirement, the mark of this form is obtained as:

- the weighting of the average mark of the exam (75%), the average score of the laboratory (15%) and the average mark of the activities (10%) provided that the exam mark is equal to or greater than 4 (over 10).

The subject is considered passed when the grade obtained is equal to or greater than 5 (over 10).

In any case, the evaluation system will be governed by the Reglament d'Avaluació i Qualificació de la Universitat de València per a Títols de Grau i Màster (http://links.uv.es/j0Im3ec).

REFERENCES

Basic

- Control e Instrumentación de Procesos Químicos; P. Ollero, E. Fernández (Editorial Síntesis, 1997)
- Ingeniería de Control Moderna; K. Ogata (4ªEd.,Prentice-Hall, 2005)

Additional

- Chemical Process Control. An Introduction to Theory and Practice; G. Stephanopoulos (Prentice-Hall, 1984)
- Process Dynamics and Control; D.E. Seborg, T.F. Edgar, D.A. Mellichamp (Wiley, 1989)
- Principles and Practice of Automatic Process Control; C.A. Smith, A.B. Corripio (Wiley, 1985)
- Process Systems Analysis and Control; D.R. Coughanowr, L.B. Koppel (McGraw-Hill, 1965)
- Retroalimentación y Sistemas de Control; J.J. Distéfano III, A.R. Stubberud, I.J. Williams (McGraw-Hill, 1992)