COURSE DATA

Data Subject	
Code	34929
Name	Process dynamics and control
Cycle	Grade
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
1404 - Degree in Industrial Electronic Engineering	School of Engineering	3	First term

Subject-matter

Degree	Subject-matter	Character
1404 - Degree in Industrial Electronic Engineering	12 - Dynamics and control	Obligatory

Coordination

Name	Department
ESPI HUERTA, JOSE MIGUEL	242 - Electronic Engineering

SUMMARY

This is an obligatory subject taught in the first semester of the third curse of the Industrial Electronics Engineering degree. It weights 6 ECTS (European credits). The student dedication is estimated in 150 hours, from which 60 are classroom hours and 90 are non-classroom hours.

This subject configures by itself the whole matter “Dinámica y Control”. It is a multidisciplinary subject that intends to give a global and practical overview of feedback systems.

The subject provides the student the theoretical and practical concepts needed to solve problems in the field of control systems, i.e. to analyze and implement feedback control systems, which are typically

present in electronic equipment or in industrial production processes.

The subject aims to give the means to the students to analyze and design control systems. The process modelling and its feedback control are undertaken. There are presented the graphical methods (block and flux diagrams) used to represent feedback systems, and the methods utilized to analyze their stability. Finally the standard methods to design analog PID compensators are described.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

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

Other requirements

The recommended previous knowledge to follow this subject is:
-Basic contents related with complex variable and Laplace transform, which are taught in the 1st curse subjects Matemáticas I and II.
-Circuit network theory, frequency response and transfer function concepts, intrinsic to the 1st curse subject Teoría de Redes Eléctricas.
-Analog electronic basics, treated in the 2nd curse subject Tecnología Electrónica.
-The Newton physics equations for translational and rotational dynamics, covered in

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

1404 - Degree in Industrial Electronic Engineering

- CG3 - 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.
- CG4 - 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 (with specific industrial electronics technology).
- CG23 - Knowledge of the fundamentals of automatic mechanisms and control methods.

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

After having passed the subject, the student should have earned a bundle of skills, among which are:

- Be able to obtain mathematical models of most typical industrial processes (CG3).
- Know and manage with the block and flux diagrams that represent feedback systems (CG3).
- Analyze whether a feedback system is stable or not, and if it isn't, determine its stability margins (CG23).
- Know the different types of compensators that can be used (CG23).
- Design and implement the feedback compensation attending to specifications in the time and frequency (CG4, CG23).

DESCRIPTION OF CONTENTS

1. Introduction to Feedback Control

- Terminology and definitions.
- Examples of control systems.
- History of automatic control.

2. Systems Dynamics

- Introduction.
- Modeling. Obtaining nonlinear differential equations.
- Linearization. Obtaining transfer functions.
- First order systems without zeros. Settling time.
- First order systems with zero.
- Second order systems without zeros. Overdamped system. Underdamped system. Damping coefficient. Overshoot. Frequency response.
- Second order systems with zero.
- Equivalent reduced order system.

3. Drawing and Calculation of Feedback Systems

- Block diagrams: Basic feedback. Loop gain and closed loop gain. Error signal. Rules of graphic simplification. Examples.
- Properties of the feedback systems: Sensitivity. Accuracy. Dynamic correction.
- Signal flow graphs: Rules of graphic simplification. Examples. Transformation of block diagrams to signal flow graphs. Mason's rule. Application examples.

4. Steady-State Analysis of Feedback Systems

- Introduction. Static relationships in a non-linear process.
- Steady-state analysis. Static model of the actuator, process and sensor. Steady-state analysis of the feedback system. Examples.
- Unitary errors: position, speed and acceleration errors. Type 0, 1 and 2 systems.
- Conclusions.

5. Stability of Feedback Systems

- Introduction.
- Closed loop stability: Characteristic polynomial. Necessary condition of stability.
- Absolute stability analysis: Routh-Hurwitz criterion.
- Relative stability analysis: Nyquist stability criterion. Nyquist diagram.
- Phase and gain margins. Margin-based stability. Stability and delays.
- Relationships between open-loop and closed-loop characteristics: Closed-loop Bode diagrams. Settling time and gain crossover frequency. Overshoot and phase margin.

6. Design of Feedback Control Systems

- Introduction.
- Types of analog compensators: P, I, D, PD, PI, PI + pole, PID, Leading, Lagging, Lagging-Leading, PID+pole, PID+2 poles.
- Design based on the loop gain frequency response: Design specifications on the loop gain Bode. Determination of the appropriate type of compensator. Examples.
- Asymptotic frequency design. Design examples.
- Analytical frequency design. Need for pre-filter. Design examples.
- Design on the root locus: Calculation of the dominant poles. Angle and magnitude conditions. Design examples.
- Application example.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	30,00	100
Laboratory practices	20,00	100
Classroom practices	10,00	100
Development of group work	15,00	0
Study and independent work	40,00	0
Readings supplementary material	5,00	0
Preparing lectures	5,00	0
Preparation of practical classes and problem	25,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

THEORY CLASSES.

The theory classes will be taught masterfully. After the introduction of new content, its application will be illustrated with practical examples (CG3, CG23). Afterwards, the teacher will be able to propose a related problem as homework (CG4, CG23), which will be solved in the following problems class.

PROBLEMS CLASSES.

During the problems classes, the teacher will solve example problems and all the problems proposed to the students as homework.

LABORATORY CLASSES.

They are taught in the ETSE's lab facilities, which are equipped with specific electronic equipment and computers. Students will be organized in groups of 2 or 3. There will be a descriptive guide of each practice.

EVALUATION

In the first call the student will be able to choose between two evaluation modalities: continuous evaluation or evaluation by final exam. In the second call the student will always be evaluated by the final exam modality. Both evaluation modalities are detailed below.

a) CONTINUOUS EVALUATION:

- Evaluation of the theory-problems part:

Two partial exams will be held: the first in the middle of the semester, and the second on the day set by the center for the first-call exam. Students who pass the first part will only have to take the contents of the second part of the subject in the second partial exam, and their Theory-Problems grade (*grade_theorpro*) will be obtained as the arithmetic mean of both parts. Students who fail the first part will have to take the entire subject in the second partial exam, obtaining *grade_theorpro* directly from that exam.

- Evaluation of the laboratory part:

The continuous evaluation of the laboratory practices will be carried out and the *grade_pract* (out of 10) will be obtained as the arithmetic mean of all of them.

A laboratory exam will be carried out, which, if passed, determines the *grade_test* (out of 10). Otherwise *grade_test* = 0.

The final lab grade will be calculated as:

grade_lab = 0.7**grade_pract* + 0.3**grade_test*.

b) Evaluation by FINAL EXAM:

A final theory-problem exam and a laboratory exam will be held on the date set by the center, obtaining the *grade_theorpro* and *grade_lab* directly from these exams. To be able to take advantage of this modality in the first call, the student must indicate it to the laboratory professor at the beginning of the classes, to avoid being evaluated by him continuously, and will not have to take the first partial exam of theory-problems.

Regardless of the evaluation modality chosen, a minimum of 5 (out of 10) will be necessary both in theory-problems (*grade_theorpro*) and in laboratory (*grade_lab*) to pass. In that case, the final grade for the course will be obtained as follows:

Final_grade = (2**grade_theorpro* + *grade_lab*)/3.

Otherwise: *Final_grade* = min(*grade_theorpro*, *grade_lab*).

In any case, the evaluation system will be governed by the provisions of the Regulation of Evaluation and Qualification of the University of Valencia for Degrees and Masters.

REFERENCES

Basic

- b1: Ingenieria de Control Moderna. Katsuhiko Ogata. Ed. Pearson. ISBN: 9788483226605. ISBN (e-book): 9788483229552. http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=1259
- b2: Sistemas de Control Moderno. Richard C. Dorf. Ed. Pearson. ISBN: 9788420544014.