Universidad de Alcalá

TEACHING GUIDE

Control Engineering II

Degree in
Industrial Electronics and Automatics Engineering

Universidad de Alcalá

Academic Year 2022/2023

3rd Year - 1st Semester

Approved by the School Board on June 3, 2022

TEACHING GUIDE

Course Name:	**Control Engineering II**
Code:	**600016**
Degree in:	**Industrial Electronics and Automatics Engineering**
Department and area:	**Automática** **Systems Engineering and Automation**
Type:	**Compulsory**
ECTS Credits:	**6.0**
Year and semester:	**3rd Year, 1st Semester**
Teachers:	Iván García Daza
Tutoring schedule:	Consultar al comienzo de la asignatura
Language:	English

1. COURSE SUMMARY

The course Control Engineering II aims to provide students with an intermediate level of principles of design of linear control systems in time and frequency domains, both continuous time and discrete time. It attends in turn as a bridge to more advanced and applied materials later in the fields of automation and robotic systems courses.

The course promotes understanding of the basic concepts of control. Moreover, it seeks training for problem analysis, combining systematic methodologies with the approach and discussion of alternatives. Given the practical nature that this subject has, it is raised a set of laboratory practices that will strengthen the fundamental theoretical aspects, using examples of actual control systems.

Prerequisites and Recommendations

For a good use of the subject, knowledge and skills of Linear Algebra and Differential Equations, Physics I, Physics II, Mechanical Systems and Automation Basic, taught in the first two degree courses, are required.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/351/2009:

en_TR2 - Knowledge in basic and technological subjects, which enables them to learn new methods and theories, and gives them versatility to adapt to new situations.

en_TR3 - Ability to solve problems with initiative, decision making, creativity, critical reasoning and to communicate and transmit knowledge, skills and abilities in the field of Industrial Engineering.

en_TR4 - Knowledge to carry out measurements, calculations, assessments, appraisals, appraisals, studies, reports, work plans and other similar works.

en_TR5 - Ability to handle specifications, regulations and mandatory standards.

en_TR9 - Ability to work in a multilingual and multidisciplinary environment.

en_TRU1 - Capacity of analysis and synthesis.

en_TRU2 - Oral and written competencies.

en_TRU3 - Ability to manage information.

en_TRU4 - Autonomous learning skills.

en_TRU5 - Team work.

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/351/2009:

en_CEI7 - Knowledge and capacity for modeling and simulation of systems.

en_CEI8 - Knowledge of automatic regulation and control techniques and their application to industrial automation.

en_CEI11 - Ability to design control systems and industrial automation.

General skills

This course helps to acquire the following generic competencies defined in paragraph 3 of the Annex to the Order CIN/351/2009:

TR2: Knowledge in basic materials and technology that will enable students to learn new methods and theories, and equip them with versatility to adapt to new situations.

TR3: Ability to solve problems with initiative, decision making, creativity, critical thinking and to communicate and transmit knowledge, skills and abilities in the field of Industrial Engineering.

TR4: Knowledge to perform measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and similar work.

TR5: Knowledge to manage documentation, specifications, and mandatory regulations.

TR6: Ability to work in a multilingual and multidisciplinary environment

Profesional skills

This course helps to acquire the following competences of professional character as defined in Section 5 of the Annex to the Order CIN/351/2009:

CEI7: Knowledge and ability to perform system modelling and simulation.

CEI8: Knowledge of automatic control and control techniques and its applicability to the industrial automation context.

CEI11: Knowledge and ability to design control and industrial automation systems.

Learning Outcomes

After succeeding in this subject the students will be able to:

RAAC9. To apply the control theory knowledge to solve controllers design problems in both discrete and continuous time.

RAAC10. To be able to use computer tools to design control systems.

RAAC11. To be able to model, design and simulate linear and dynamic control systems in both discrete and continuous time.

RAAC12. To design lineal control systems in both the continuous and discrete time domain, as well as in the frequency domain.

RAAC13. To recognise the basic principles related with the design of linear controllers in continuous and discrete time domains.

3. CONTENTS

Contents Blocks	Total number of hours
Controller system design using root-locus methods; preliminary design considerations; phase lead compensator; phase lag compensator; phase lead-lag compensator; vertical method; pole/cero cancellation method; bisector method; PID controller design base on steady and transient response specifications; hierarchical design in control system	7 hours
Controller system design using frequency response; lead phase compensation; lag phase compensation; phase lead-lag compensation; preliminary concepts about multivariable controller system. Transport delay analysis.	7 hours
Discrete control system design; introduction, mathematical concepts, Z transform; Z transform theorems; relationship between Z and s planes; stability study; final value theorem; discretization techniques of continuous control systems P, I, PD, PI and PID controllers discretization process; zero-pole equalization method; digital PID regulator design; rectangular approximation, trapezoidal approximation; root-locus to system on discrete time, basic equations and design rules	21 hours
Discrete time controller design using direct methods; discrete time controller design base on root-locus methods; analytical design methods. Designing MPC controllers.	21 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (56 hours on-site +2 exams hours)
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

The teaching strategy of the course is divided into 5 sections, such as it is enumerated:

Theoretical sessions

Methodology: master classes where the teacher presents and explains the theoretical aspects, complemented by practical examples. Student participation will be encouraged from the theoretical concept developments, to the resolution of the proposed practical examples and the discussion of real cases.

Resources: blackboard, audiovisual media, internet, bibliography

Practical problem solving sessions

Methodology: master classes of troubleshooting workshops combined with group and individual workshops. Small group discussion to reach the problem approaching and to look for the relation with theory. Written and oral presentation of alternative resolutions. Sharing of proposed resolutions.

Resources: blackboard, audiovisual, bibliography

Hands-on labs

Methodology: Groups of 3 persons maximum to work. Initial explanation and general discussion of the practice, collaborative work in each group with the teacher's guide, management and good use of the material, obtaining results, interpretation and presentation.

Resources: blackboard, audiovisual, instrumentation and laboratory equipment.

Tutorials and seminars

Individual and/or group tutorials on the theoretical and practical subject contents

Non-contact activities

Troubleshooting and practices applying theoretic concepts, literature search, group work

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Learning Assesment Guidelines, LAG, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Learning Assesment Guidelines as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

Ordinary Call

The evaluation in the ordinary call must be inspired by the continuous evaluation criteria (regulatory rules of the Teaching Learning Process, NRPEA, art 3), always attending to the acquisition of the competences specified in the subject:

Continuous Assessment:

The main assessment tools will be:

- **Problems**. Solving practical problems individually.
- **Laboratory Exercises**. Performance of laboratory practices and delivery of the corresponding reports. The evaluation will consider systematic observation, where the teacher will record the main difficulties and skills observed in each student, and the realisation of a single memory by practice, by each of the groups of students who have done it.
- **Assessment Tests**. Performing written tests focused on both practical and theoretical aspects of the subject.

Students must attend 100% of the laboratory sessions and deliver the corresponding reports to all laboratory practices. Recovery sessions will be enabled for those students who have not attended any of the sessions and justify it documentarily.

The students, as a group, will deliver the reports of the laboratory practices following the established schedule. These practices will be evaluated by the professor responsible for the laboratory group, to assess if the objectives indicated in the script of the same have been met.

Assessment through final exam:

In the case of evaluation by means of a final exam, the evaluation elements to be used will be the following:

- **Final Evaluation Test**: based on the resolution of design problems of control systems theory.

Extraordinary Call

The procedure will be the same as that described for the assessment by means of a final exam in the ordinary call.

5.2. EVALUATION

EVALUATION CRITERIA

The assessment criteria measure the level in which the competences have been acquired by the student. For that purpose, the following are defined::

CE1. The student shows ability to solve mathematical problems in engineering.

CE2. The student shows ability, based on theoretical questions for the understanding and mastery of the basics of the general laws of various branches of engineering.

CE3. The student shows ability to design control systems and industrial automation and industrial application.

GRADING TOOLS

The work of the student is graded in terms of the assessment criteria above, through the following tools:

Ordinary call:

1. Continuous assessment:
   a. **Intermediate Evaluation Tests (PEI1, PEI2)**
   b. **Laboratory works (PL)**
2. Final assessment:
   a. **Final Evaluation Test (PEF)**

Extraordinary call:

1. **Final Evaluation Test (PEF)**

Intermediate Evaluation Tests (PEI1, PEI2): based on the resolution of design problems of control systems and industrial automation and its industrial application.

Lab works (PL): based on the accomplishment of lab works and laboratory tests of design, simulation.

Final Evaluation Test (PEF): based on the resolution of design problems of control systems and industrial automation and its industrial application

GRADING CRITERIA

In the ordinary call-continuous assessment the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR2-TR5, TR9, CEI8, CEI11	RAAC9, RAAC12, RAAC13	CE1, CE2	PEI1	30%
TR2-TR5, TR9, CEI7	RAAC10, RAAC11	CE3	PL	30%
TR2-TR5, TR9, CEI8, CEI11	RAAC9, RAAC12, RAAC13	CE1, CE2	PEI2	40%

In the ordinary call-final evaluation, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR2-TR5, TR9, CEI7, CEI8, CEI11	RAAC9, RAAC10, RAAC11, RAAC12, RAAC13	CE1, CE2, CE3	PEF	100%

Extraordinary call

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR2-TR5, TR9, CEI7, CEI8, CEI11	RAAC9, RAAC10, RAAC11, RAAC12, RAAC13	CE1, CE2, CE3	PEF	100%

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- Katsuhiko Ogata. Modern Control Engineering. Fifth edition. Prentice Hall, 2010.
- Katsuhiko Ogata. Discrete-Time Control Systems. Second edition. Prentice-Hall International, 1995.
- Farid Golnaraghi, Benjamin C. Kuo. Automatic Control Systems. Ninth edition. Wiley, 2009.
- Material docente preparado por el profesorado para la asignatura, proporcionado a los alumnos a través de la plataforma Aula Virtual (BlackBoard).

6.2. Additional Bibliography

- Richard Carl Dorf, Robert H. Bishop. Modern Control Systems. Twelfth edition. Pearson, 2011.
- Alberto Cavallo, Roberto Setola, Francesco Vasca. Using MATLAB, SIMULINK and Control SystemToolbox: a practical approach. Second edition. Prentice Hall, 1999.
- Dean K. Frederick, Joe H. Chow. Feedback control problems: using MATLAB and the Control SystemToolbox. Second edition. Brooks/Cole, 2000.
- KatsuhikoOgata. Matlabfor Control Engineers. Prentice Hall, 2007.
- Rao V. Dukkipati. MATLAB: An Introduction with Applications. New Age International, 2010.
- David Koenig. Practical Control Engineering: Guide for Engineers, Managers, and Practitioners. McGraw Hill Proffesional, 2009.
- A. Rodríguez Núñez, J. M. Bañón, T. Martínez Marín. Sistemas de Control. Ejercicios resueltos. Servicio de publicaciones de la UAH.
- A. Moreno-Muñoz, Trabajando con MATLAB y la Control System Toolbox. Editorial RA-MA.

Disclosure Note

The University of Alcalá guarantees to its students that, if due to health requirements the competent authorities do not allow the total or partial attendance of the teaching activities, the teaching plans will achieve their objectives through a teaching-learning and evaluation methodology in online format, which will return to the face-to-face mode as soon as these impediments cease.