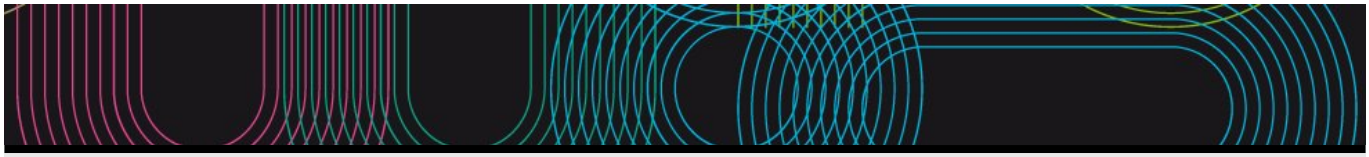

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Automation and Control Fundamentals** | | | | |
| Subject | Automation and Control Fundamentals | | | |
| Code | V12G320V01405 | | | |
| Study programme | (*)Grao en Enxeñaría Eléctrica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 6 | Mandatory | 2nd | 2nd |
| Teaching language | Spanish | | | |
| Department | | | | |
| Coordinator | Vázquez Núñez, Fernando Antonio | | | |
| Lecturers | Vázquez Núñez, Fernando Antonio | | | |
| E-mail | fvazquez@uvigo.es | | | |
| Web | | | | |
| General description | This matter presents the basic concepts of the systems of industrial automation and of the methods of control, considering like central elements of the same the programmable automaton and the industrial regulator, respectively. | | | |

| Competencies | |
|---|---|
| Code | |
| B3 | CG3 Knowledge in basic and technological subjects that will enable students to learn new methods and theories, and provide them the versatility to adapt to new situations. |
| C12 | CE12 Know the fundamentals of automation and control methods. |
| D2 | CT2 Problems resolution. |
| D3 | CT3 Oral and written proficiency in the own language. |
| D6 | CT6 Application of computer science in the field of study. |
| D9 | CT9 Apply knowledge. |
| D16 | CT16 Critical thinking. |
| D17 | CT17 Working as a team. |
| D20 | CT20 Ability to communicate with people not expert in the field. |

| Learning outcomes | | | |
|---|---|---|---|
| Expected results from this subject | Training and Learning Results | | |
| Obtain a detailed and realistic vision of the current state of control and industrial automation systems. | B3 | C12 | D6<br>D9<br>D16 |
| Know which are the elements that constitute an industrial automation system, how they work and how the are dimensioned. | B3 | C12 | |
| Capacity to design and project a complete automation system. | | C12 | D2<br>D3<br>D6<br>D9<br>D17<br>D20 |
| Understand the fundamentals of programmable logic controllers and their application in automating different types of industrial plants. | | C12 | D2<br>D6<br>D9<br>D16 |

| Contents |
|---|
| Topic |

| | |
|---|---|
| 1. Introduction to industrial automation (2,5C) | Introduction to issues that will allow the student to value the capabilities and knowledge that will be obtained during the course.<br>1.1 Course presentation.<br>1.2 Why are industrial processes automated?<br>1.3 Historical evolution of automation: from regulating simple movements to supply chain management.<br>1.4 Economic and social impact.<br>1.5 Role of the Electrical Engineer.<br>1.6 Types of automation and examples. |
| 2. Automation elements (2C) | Presentation of the elements that are commonly used to automate industrial processes.<br>2.1 Sensors<br>2.1.1 Presence<br>2.1.2 Rotation and speed<br>2.1.3 Translation<br>2.1.4 Encoder<br>2.1.4 Others: temperature, pressure, etc.<br>2.2 Simple actuators<br>2.2.1 Electrical engines<br>2.2.2 Cylinders<br>2.2.3 Pumps<br>2.2.4 Valves<br>2.2.5 Contactors<br>2.3 Complex actuators<br>2.3.1 Linear actuators<br>2.3.2 Two-axis actuators<br>2.3.3 Conveyors<br>2.3.4 Cranes<br>2.3.5 Robots and manipulators<br>2.3.6 In-plant transport systems<br>2.3.7 In-plant storage systems<br>2.4 Plant control elements<br>2.4.1 Industrial regulator<br>2.4.2 Frequency variator<br>2.4.3 Automaton<br>2.4.4 Control by PC<br>2.4.5 Industrial communications<br>2.5 Monitoring and management systems.<br>2.5.1 SCADA<br>2.5.2 MES |
| 3. Introduction to programmable logic controllers (2C) | Introduce basic concepts relative to the design and development of automation systems based on Programmable Logic Controllers (PLC)<br>3.1 Basic concepts<br>3.1.1 Physical and logical architecture<br>3.1.2 Numbering systems<br>3.1.3 Program cycle<br>3.1.4 Set-up<br>3.1.5 Modular programming<br>3.2 Basic elements<br>3.2.1 Inputs<br>3.2.2 Outputs<br>3.2.3 Memory<br>3.2.4 Counters<br>3.2.5 Timers<br>3.3 Operations<br>3.3.1 Memory transfer<br>3.3.2 Combinatorial logic<br>3.3.3 Arithmetic<br>3.4 Low level languages<br>3.5 High level languages<br>3.6 Advanced functions |

| | |
|---|---|
| 4. Low level programming of PLCs (6C) | Students learn to develop binary automation systems using a contact diagram language<br>4.1 Contact diagrams concepts<br>4.2 Binary variables<br>4.3 Combinatory systems<br>4.4 Sequential systems<br>4.5 Arithmetic operations<br>4.6 Counters<br>4.7 Timers<br>4.8 Examples |
| 5. Systems modeling for programming PLCs (8C) | Students learn to model binary automation systems using Petri Nets and Grafcet.<br>5.1 Basic principles. Modeling techniques.<br>5.2 Modeling using Petri Nets.<br>5.2.1 Definition of stages and transitions. Rules of evolution.<br>5.2.2 Conditional selection of alternatives.<br>5.2.3 Simultaneous sequences. Concurrence. Shared resource.<br>5.3 Implementation of Petri Nets.<br>5.3.1 Direct implementation<br>5.3.2 Normalized implementation (Grafcet)<br>5.4 Design of basic industrial automation systems.<br>5.5 Examples. |
| 6. Introduction to the automatic regulation and systems modeling (4C) | Introduce the basic concepts related to automatic regulation of continuous linear systems<br>6.1 Open loop and closed loop regulation systems.<br>6.2 The typical regulation loop. Nomenclature, definitions and specifications.<br>6.3 Physical systems and mathematical models.<br>6.3.1 Mechanical Systems.<br>6.3.2 Electrical Systems.<br>6.3.3 Others.<br>6.4 Transfer function modeling.<br>6.4.1 Laplace Transform.<br>6.4.2 Properties.<br>6.4.3 Examples. |
| 7. Continuous process control (6C) | Students learn to design and tune industrial regulators.<br>7.1 Continuous linear controllers.<br>7.1.1 Control actions: proportional, integral and derivative.<br>7.1.2 PID regulator.<br>7.2 Empirical methods for tuning industrial regulators.<br>7.2.1 Open loop tuning.<br>7.2.2 Closed loop tuning.<br>7.3 Examples. |
| 8. Process control using a PLC (2C) | Students learn to implement a PID using a PLC<br>8.1 Functional blocks for process control<br>8.2 PID implementation.<br>8.3 Monitoring and control software (SCADA). |
| P1. Introduction to STEP7 and programming languages (2L) | Introduction to the STEP7 environment, that allows programming Siemens series S7-300 and S7-400 PLCs, as well as testing them, storing them, modifying them, etc... Familiarization with the environment, hardware configuration and low level programming languages, by implementing a simple example. |
| P2. Direct modelling and implementation (2L) | Model a simple automation example and implement it as a contact diagram. |
| P3. Petri Net modelling and implementation (6L) | Model a more complex example and implement it in one of the languages available in STEP7. |
| P4. S7-Graph modelling and implementation (2L) | Normalized modelling and implantation of a Petri Net with S7-Graph. |
| P5. Introduction to the design of control systems with Matlab/Simulink (2L) | Introduction to the basic elements of Matlab/Simulink as well as to the control toolbox.<br>Analyze and simulate the transitory response of first and second order continuous systems. |
| P6. Analysis and control of systems using Matlab and Simulink (2L) | Analysis and simulation of linear control systems with Matlab/Simulink. |
| P7. Industrial regulator tuning (2L) | Determination of the parameters of a PID regulator using the methods studied in class. Implementation in an industrial regulator connected to a personal computer where the plant model is simulated. |

## Planning

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Troubleshooting and / or exercises | 0 | 10 | 10 |
| Laboratory practises | 18 | 27 | 45 |
| Master Session | 32.5 | 32.5 | 65 |
| Long answer tests and development | 3 | 19 | 22 |

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

| | Description |
|---|---|
| Troubleshooting and / or exercises | The profesor will solve problems and exercises in the classroom and the students will have to resolve similar exercises to obtain the necessary skills |
| Laboratory practises | Concepts explained in the classroom are applied to specific situations and solved using tools commonly found in the workplace |
| Master Session | Exhibition by part of the professor of the contents of the matter |

## Personalized attention

| Methodologies | Description |
|---|---|
| Master Session | In order to achieve an effective use of the students' time, the profesor will personally solve their doubts and questions. This will occur during lectures and laboratory classes as well as in tutorships. To attend tutorships, the students will have to previously establish an appointment with the professor. For this, he will have to send him an and-mail describing his specific doubts. When possible, the professor will try to resolve the doubts by e-mail and will put a copy of the question and response in Faitic so that all the students can see them. If necessary, the profesor will assign a slot of time on a specific date to meet in person with the student. The professor will not provide tutorship sessions without a previous appointment. The students also will be able to formulate his doubts through *Faitic. |
| Troubleshooting and / or exercises | In order to achieve an effective use of the students' time, the profesor will personally solve their doubts and questions. This will occur during lectures and laboratory classes as well as in tutorships. To attend tutorships, the students will have to previously establish an appointment with the professor. For this, he will have to send him an and-mail describing his specific doubts. When possible, the professor will try to resolve the doubts by e-mail and will put a copy of the question and response in Faitic so that all the students can see them. If necessary, the profesor will assign a slot of time on a specific date to meet in person with the student. The professor will not provide tutorship sessions without a previous appointment. The students also will be able to formulate his doubts through *Faitic. |
| Laboratory practises | In order to achieve an effective use of the students' time, the profesor will personally solve their doubts and questions. This will occur during lectures and laboratory classes as well as in tutorships. To attend tutorships, the students will have to previously establish an appointment with the professor. For this, he will have to send him an and-mail describing his specific doubts. When possible, the professor will try to resolve the doubts by e-mail and will put a copy of the question and response in Faitic so that all the students can see them. If necessary, the profesor will assign a slot of time on a specific date to meet in person with the student. The professor will not provide tutorship sessions without a previous appointment. The students also will be able to formulate his doubts through *Faitic. |

## Assessment

| | Description | Qualification | Training and Learning Results | | |
|---|---|---|---|---|---|
| Laboratory practises | Continuous evaluation of each student's work will be assed during a total of 9 lab sessions, scoring each session between 0 and 10 points. The grade for lab practices will be the average of the scores obtained in the sessions. | 30 | | C12 | D2<br>D6<br>D9<br>D16<br>D17<br>D20 |
| Long answer tests and development | Each final examination will include a test of 10 questions and a problem. | 70 | B3 | C12 | D2<br>D3<br>D9<br>D16 |

## Other comments on the Evaluation

For each session the profesor will establish specific targets/deliverables, even when the practice covers several sessions.

Evaluation of practical sessions:

- Assistance: 3 points
- Participation: 2 points
- Approach of the problem and of the solution: 2 points
- Correct solution: 3 points

The grade for laboratory practices is saved for the second evaluation if the student has passed them and does not decline continuous evaluation.It is not saved for other course years.
Students that have passed the practices during the continuous evaluation will be able to pass the subject if their score in the exam is of at least 3 points and the total is at least 5 points.
Students that have not passed the practices during the continuous evaluation or decline, will have to pass a practical examination if they pass the final examination (5 points over 10) in any one of the two final course evaluations.

Ethical commitment: It is expected an adequate ethical behaviour of the student. In case of detecting unethical behaviour (copying, plagiarism, unauthorized use of electronic devices, etc.) shall be deemed that the student does not meet the requirements for passing the subject. In this case, the overall rating in the current academic year will be Fail (0.0).

## Sources of information

**Básic:**

"Autómatas Programables y Sistemas de Automatización",

E.MANDADO, J.MARCOS, CELSO FERNANDEZ, J.I.ARMESTO, Ed. Marcombo 2009

*Las Redes de Petri en la Automática y la Informática* , MANUEL SILVA Editorial AC

"*Sistemas de control modernos*", DORF, BISHOP, Ed. Addison-Wesley.

**Additional:**

"Autómatas Programables. Fundamento. Manejo. Instalación y Práctica",

PORRAS, A., MONTERO, A.P., Ed. McGraw-Hill, 1990.

"*Automatización. Problemas resueltos con autómatas programables*, J. Pedro Romera, J. Antonio Lorite, Sebastián Montoro. Ed. Paraninfo

*Guía usuario Step7* SIEMENS

*Diagrama de funciones (FUP) para S7-300 y S7-400* SIEMENS

*SIMATIC S7-GRAPH para S7-300/400* SIEMENS

"*Control de sistemas continuos. Problemas resueltos*", Barrientos, Ed. Mcgraw-Hill.

"*Ingeniería de control moderna*", Ogata, K., Ed. Prentice-hall.

"*Retroalimentación y sistemas de control*", DISTEFANO, J.J., STUBBERUD, A.R., WILLIAMS, I.J., Ed. McGraw-Hill.

## Recommendations

### Other comments

Requirements: To register for this module the student must have passed or be registered for all the modules of the previous year.