UAB
Universitat Autònoma de Barcelona

Cyber-Physical Systems

Code: 104544
ECTS Credits: 6

2024/2025

Degree	Type	Year
2500001 Management of Smart and Sustainable Cities	OB	3

Contact

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

For the full understanding of the contents of the course, it is convenient to have a basic ability in programming and a good knowledge of how programs execute in computers. For this, you should have completed Computer science, Internet applications' programming, and Digitalization and microcontrollers courses.

Objectives and Contextualisation

This subject is the first within the subject of Cyber-Physical Systems, in which cities are treated as proper cyber-physical systems where software is combined with the city. In this sense, the data that is collected from urban environments is transmitted and processed for decision making, which ultimately ends up in control actions that affect the same urban environments.

In this context, the Cyber-physical systems' course objective is that students acquire the following competences:

- Know how control loop closes in urban cyber-physical systems.
- Have notions of the usual requirements of cyber-physical systems, including real-time ones.
- Understand the aspects of security, reliability and robustness of the systems.
- Know the software development methodology of the cyber-physical systems.
- Understand the different computational models of the systems.

- Have practical skills with the design and manipulation of state-oriented computational models.
- Know how to estimate implementation costs from the computational models of the systems.
- Have the rudiments of programming for the implementation of control software in cyber-physical systems.

Competences

- Critically analyse work carried out and demonstrate a desire to improve.
- Design platforms of management, integration of public and government services applying technologies and systems of sensorization, acquisition, processing and communication of data.
- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
- Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.

Learning Outcomes

1. Analyse the behaviour of cyberphysical systems through simulation and the measurement of real data.
2. Critically analyse work carried out and demonstrate a desire to improve.
3. Describe the basic principles of cyberphysical-system behaviour.
4. Design cyberphysical systems for the management of intelligent cities.
5. Interpret the mechanisms of monitoring and control in cyberphysical systems.
6. Relate the elements that intervene in the model of an intelligent city with those of cyberphysical systems, including problems deriving from information management.
7. Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
8. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.

Content

- Introduction to cyber-physical systems
- Modeling of physical systems: continuous and hybrid systems
- Modeling of computer systems and control
- Architecture of cyber-physical systems
- Programming of cyber-physical systems and simulation
- Multi-agent systems

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Attendance and participation in theory classes	22	0.88	3, 5, 6
Laboratory: Course project development	12	0.48	1, 2, 4, 7

Problem solution proposals and discussion	12	0.48	1, 2, 4
Type: Supervised			
Course project follow-up	6	0.24	1, 2, 4, 8
Tutoring: Additional problem-solving activities	6	0.24	1, 2, 4
Type: Autonomous			
Course project development and report writing	12	0.48	1, 4, 8
Problem-solving	24	0.96	1, 2, 4
Study	26	1.04	2, 3, 5, 6

Teaching is structured in the following face-to-face activities:

- Theory classes: Presentations of course contents, with a first part that is devoted to the dissemination of the necessary knowledge for the analysis and the design of cyber-physical systems, and to explain cases that situate in context the knowledge and the abilities that are acquired during the course. The second part will be devoted to the discussion of problems that will be dealt with in the corresponding seminars.
- Problem-solving seminars: Discussion of small case studies that serve to consolidate knowledge regarding the analysis, design, and development of cyber-physical systems.
- Laboratory practices: Teamwork at laboratory, following a walk-through guide under the supervisions of a teacher. Each session will deal with a specific aspect regarding the implementation of cyber-physical systems.

There is a very important part of teamwork outside the classroom and the laboratory. In this sense, each member of each team will have to assume different roles for each assignment. This also means having to work in an organized way and know how to work autonomously when appropriate.

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.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Continuous assessment tests (3)	25	6	0.24	3, 4, 5, 6
Final examn	50	2	0.08	3, 4, 5, 6
Final project report and defense	12,5	10	0.4	1, 2, 4, 7, 8
Follow-up project reports (5)	12,5	10	0.4	1, 2, 4

Make-up exam	50	2	0.08	3, 4, 5, 6

a) Procedure and assessment activities' plan

The assessment is continuous with specific activities (exams and assignments) throughout the course. These assessment activities generate a series of grades that determine the final grade.

The calculation of the final grade, *n*, follows the expression:

$$n = \max(x \cdot 50\% + c \cdot 25\%, x \cdot 75\%) + p \cdot 25\%$$

where *x*, *c*, and *p* are the grades of the exam, continuous assessment, and lab project parts, respectively.

If the continuous assessment grade is smaller than the exam grade, $c < x$, the final grade does not take it into account. Therefore, the final grade is the maximum between the final grade with and without continuous assessment.

If $x < 5$ or $p < 5$, the final grade (*n*) is at most 4.5. In other words, the exam and the lab project must be passed separately.

The project grade (*p*) is obtained from the weighted average of the grades corresponding to each practice session. Six are planned. In case of non-attendance, the absent person will have a 0 as a grade for the corresponding session.

The exam grade (*x*) is the final exam grade, which can be recovered in a second exam.

The continuous assessment grade (*c*) is obtained from a weighted average of the continuous assessment tests taken throughout the course. Three are planned.

Grades on continuous assessment tests can be increased with benefits gained from active participation in problem seminars. Information regarding the mechanisms for obtaining these bonuses will be made public with due advance notice during the course.

If the continuous assessment grade is equal to or higher than 5 and the three continuous assessment tests have been taken,there is no need to take the final exam and $x = c$.

b) Assessment activities schedule

The dates of the continuous assessment theory and problem-solving tests, assignment submission deadlines will be published on the Campus Virtual (CV) and may change to adapt to eventual incidents: it will always bereported previously through the CV since it is understood that it is the usual communication platform between lecturers and students outside the classroom.

c) Re-assessment procedures

Late submissions, subject to prior notice, will be accepted and penalized with a lower grade. Late submissions without prior notice or justification of force majeure will not be accepted. A second submission period may be opened for reports that receive a negative evaluation. Unaccepted or unsubmitted assignment reports will be scored 0 and will not have the option of a second assessment.

In accordance with the coordination of the Degree and the deanship of the School of Engineering, the following activities cannot be re-assessed:

- Project, 25% of the final grade

The continuous assessment can be made up by the final examination.

There is a make-up exam for the final examination, too.

d) Assessment review procedure

Assessment activities can be reviewed any time after corresponding grades are published and before the deadline for the revision of the final exam.

Should the change of a grade be agreed upon, that grade may not be modified in a later review.

No reviews will be done after the closure of the reviews of the final exam, but for the make-up exam.

e) Grading

A "non-assessable" grade will be assigned to students that have not participated in any assessment activity nor have attended any laboratory sessions. In any other case, not participating in an assessment activity, including unattendances to lab, is scored with a 0 for calculating the weighted average.

Honourswill be awarded to those who obtain grades greater than or equal to 9.0 in each part, up to 5% of those enrolled in descending order of final grade. They may also be granted in other cases, provided that they do not exceed 5% and the final grade is equal to or greater than 9.0.

f) Irregularities, copies and plagiarism

Copies are evidences that the work or the examination has been done in part or in full without the author's intellectual contribution. This definition also includes attempts of copying in exams and reports, and violations of the norms that ensure intellectual authorship. Plagiarisms refer to the works and texts of other authors that are passed on as their own. They are a crime against intellectual property. To avoid plagiarism, quote the sources you use when writing the corresponding work reports or examinations.

In accordance with the UAB regulations, copies or plagiarisms or any attempt to alter the assessment result, for oneself of for others, like e.g. letting other copy, imply a final grade for the corresponding part (exam, continuous assessment or project) of 0 in the computation of the final score and failing the course. This does not limit the right to take action against perpetrators, both in the academic field and in the criminal.

g) Assessment of repeaters

There is no differentiated treatment for repeaters, but they can take advantage of their own material from the previous year provided it is informed in the corresponding reports.

h) Single assessment

This course does not have a single assessment procedure.

Bibliography

Edward A. Lee and Sanjit A. Seshia. (2017) *Introduction to Embedded Systems, A Cyber-Physical Systems Approach*, Second Edition, MIT Press.
A course alike but with much more theoretical background. (See also: https://ptolemy.berkeley.edu/)

Ll. Ribas Xirgo. (2014). *How to code finite state machines (FSMs) in C. A systematic approach.* TR01.102791 Embedded Systems. Universitat Autònoma de Barcelona.
[https://www.researchgate.net/publication/273636602_How_to_code_finite_state_machines_FSMs_in_C_A_syste

Explains a method to program state machines in C which resembles the one presented in the course.

Ll. Ribas Xirgo. (2011). "Estructura bàsica d'un computador", Capítol 5 de Montse Peiron Guàrdia, Lluís Ribas i Xirgo, Fermín Sánchez Carracedo i A. Josep Velasco González: *Fonaments de computadors*. Material docent de la UOC. OpenCourseWare de la UOC. [http://openaccess.uoc.edu/webapps/o2/handle/10609/12901]
It describes the state-based machine model, the algorithmic machines, and the digital systems' basic architectures that are used in the course from a different perspective, though.

M. J. Pont. (2005). *Embedded C*. Pearson Education Ltd.: Essex, England.
It shows how embedded systems are programmed, topic also treated in the course problem-solving part and laboratory. Therefore, it's an interesting complementary material.

Brian Bailey, Grant Martin and Andrew Piziali. (2007). *ESL Design and Verification. A Prescription for Electronic System-Level Methodology*. Elsevier.
It gives an overview of the embedded systems' synthesis process and situates the course material, thus it's a good complement.

Tim Wilmshurst. (2010). *Designing Embedded Systems with PIC Microcontrollers. Principles and Applications (Second Edition)*. Elsevier.
Complementary information to that of the course on an embedded system for controlling a robot.

Software

CoppeliaSim, EDU Version, Coppelia Robotics [https://www.coppeliarobotics.com/]

ZeroBrane Studio, ZeroBrane [https://studio.zerobrane.com/]

Draw.io, diagrams.net [https://app.diagrams.net/]

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	611	Catalan	first semester	afternoon
(PLAB) Practical laboratories	611	Catalan	first semester	afternoon
(PLAB) Practical laboratories	612	Catalan	first semester	afternoon
(TE) Theory	61	Catalan	first semester	afternoon