ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

593000505 - Cyberphysical Systems Modelling

DEGREE PROGRAMME

59AH - Master Universitario en Internet Of Things (Iot)

ACADEMIC YEAR & SEMESTER

2020/21 - Semester 1

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1. Description

1.1. Subject details

Name of the subject	593000505 - Cyberphysical Systems Modelling
No of credits	4.5 ECTS
Type	Compulsory
Academic year ot the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	59AH - Master Universitario en Internet Of Things (Iot)
Centre	59 - Escuela Tecnica Superior de Ingenieria y Sistemas de Telecomunicacion
Academic year	2020-21

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Agustin Yague Panadero	1119 o 6103	agustin.yague@upm.es	Sin horario. Tutoring timetable will be published when the full semester schedule is ready. Faculty can always be reached by e-mail

Juan Garbajosa Sopeña (Subject coordinator)	1205	juan.garbajosa@upm.es	Sin horario. Tutoring timetable will be published when the full semester schedule is ready. Faculty can always be reached by e-mail
Jenifer Perez Benedi	1203	jenifer.perez@upm.es	Sin horario. Tutoring timetable will be published when the full semester schedule is ready. Faculty can always be reached by e-mail

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- General knowledge about databases is recommendable

- Basic knowledge about object-oriented software modeling, like how to model with UML diagrams, is recommendable

- General knowledge about software engineering

4. Skills and learning outcomes *

4.1. Skills to be learned

CB07 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio

CB08 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios

CE.04 - Diseñar arquitecturas de alto/bajo nivel para aplicaciones IoT así como Sistemas Ciberfísicos (CPS) usando lenguajes específicos de este dominio y evaluando la interacción entre los modelos de los componentes que lo forman

CE.13 - Analizar el uso de dispositivos y servicios IoT en dominios de aplicación específicos y seleccionar los dispositivos más adecuados para el ecosistema IoT

CG03 - Los alumnos demostrarán tener las destrezas necesarias para integrar y aplicar los conocimientos adquiridos de forma que puedan desarrollar soluciones innovadoras y servicios IoT en general

CG04 - Los alumnos tendrán la capacidad de aplicar criterios de eficiencia, escalabilidad, fiabilidad y seguridad en distintos ámbitos de aplicaciones inteligentes y sistemas ciberfísicos, tales como Smart Living, Smart Cities o eHealth

CT.01 - Capacidad de uso de la lengua inglesa para el trabajo en contextos internacionales

CT.02 - Capacidad para el trabajo en grupo y dirigir, organizar y supervisar equipos multidisciplinares.

4.2. Learning outcomes

RA16 - To build microservices, configure containers and deploy microservices in containers to bring the service closer to the client

RA14 - To describe software architectures for a proposed cyber-physical system using a formal language

RA15 - To use the appropriate modeling languages to develop the detailed design of an application in the domain of cyberphysical systems and IoT

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

This course introduces modelling as a paradigm for Cyber-Physical Systems (CPS) development and Internet of Things (IoT). CPS, according to NIST, comprise interacting digital, analogue, physical, and human components engineered for function through integrated physics and logic. CPS and IoT are heavily system-based and they are usually integrated into even more complex systems called Systems of Systems such as smart cities, smart campus, smart buildings, etc. This complexity requires a rigorous requirements definition, modelling and design in order to be implemented properly. As a result, one of the main objectives of this subject is to provide students the skills of IoT systems modelling and design. In addition, the management and tracking of these systems and their devise is important. Therefore, the subject present advanced modelling technique as Model-Driven Development to manage and track devices from software platforms. Finally, services, cloud, microservices and containers are introduced as elements for CPS implementation.

5.2. Syllabus

1. Requirements Specification and Analysis of Cyber-physical and IoT systems

2. Systems/software design, architecture specification and modelling, and implementation of Cyber-physical and IoT

3. Model Driven Development (MDD) Engineering for CPS and IoT

4. Cyber-physical systems modelling using SysML

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Distant / On-line	Assessment activities
1	**Presentation Lesson** Duration: 01:00 **Lesson 1: CPS Analysis** Duration: 01:30	**Lesson 1: CPS Analysis** Duration: 01:00		
2	**Lesson 1: CPS Analysis** Duration: 02:00	**Assignment 1: Presentation to students** Duration: 01:00 **Lesson 1: CPS Analysis** Duration: 00:30		
3	**Lesson 1: CPS Analysis** Duration: 02:00	**Lesson 2: CPS Analysis** Duration: 02:30 **Lesson 1: CPS Analysis** Duration: 01:30		
4	**Lesson 2: CPS Design and Architecture** Duration: 02:00	**Lesson 2: CPS Design and Architecture** Duration: 01:30		
5	**Lesson 2: CPS Design and Architecture** Duration: 01:00	**Lesson 2: CPS Design and Architecture** Duration: 02:30		**Deliverable 1.1: Cyberphysical Systems Analysis. Report** Continuous assessment Not Presential Duration: 00:00 **Deliverable 1.1: Cyberphysical Systems Analysis. Video presentation** Continuous assessment Not Presential Duration: 00:00
6	**Lesson 2: CPS Design and Architecture** Duration: 01:30	**Lesson 2: CPS Design and Architecture** Duration: 01:00 **Presentation: Assignment 2** Duration: 01:00		

7	**Lesson 3: CPS Model Driven Development Engineering** Duration: 02:30 **Lesson 3: CPS Model Driven Development Engineering** Duration: 01:00	**Lesson 3: CPS Model Driven Development Engineering** Duration: 01:00 **Lesson 3: CPS Model Driven Development Engineering** Duration: 01:30		
8	**Lesson 3: CPS Model Driven Development Engineering** Duration: 01:30	**Lesson 3: CPS Model Driven Development Engineering** Duration: 02:00		**Deliverable 2.1: CPS Design and Architecture. Report** Continuous assessment Not Presential Duration: 00:00 **Deliverable 2.2: CPS Design and Architecture. Video presentation** Continuous assessment Not Presential Duration: 00:00
9	**Lesson 3: CPS Model Driven Development Engineering** Duration: 01:30	**Lesson 3: CPS Model Driven Development Engineering** Duration: 02:00		
10	**Tema 4:CPS Engineering with SysML** Duration: 02:30	**Tema 4:CPS MDD engineering** Duration: 01:00		
11				**Deliverable 3.1: CPS MDD engineering. Report** Continuous assessment Not Presential Duration: 00:00 **Deliverable 2.2: MDD engineering. Video presentation** Continuous assessment Not Presential Duration: 00:00
12				
13				
14				
15				
16				**Deliverable 1.CPS Analysis. Report** Final examination Presential Duration: 00:00 **Deliverable 2: CPS Design and implementation. Report** Final examination Presential Duration: 00:00 **Deliverable 3: CPS MDD enginering. Report**

				Final examination Presential Duration: 00:00
17				

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
5	Deliverable 1.1: Cyberphysical Systems Analysis. Report		No Presential	00:00	28%	4 / 10	CB07 CB08 CT.02 CG03 CT.01 CG04 CE.13
5	Deliverable 1.1: Cyberphysical Systems Analysis. Video presentation		No Presential	00:00	7%	4 / 10	CB08 CT.02 CG03 CT.01
8	Deliverable 2.1: CPS Design and Architecture. Report		No Presential	00:00	25%	4 / 10	CG04 CB07 CB08 CT.02 CE.04 CG03 CT.01
8	Deliverable 2.2: CPS Design and Architecture. Video presentation		No Presential	00:00	5%	4 / 10	CT.02 CG03 CT.01 CB08
11	Deliverable 3.1: CPS MDD engineering. Report		No Presential	00:00	27%	4 / 10	CG04 CB07 CB08 CT.02 CE.04 CG03 CT.01 CE.13
11	Deliverable 2.2: MDD engineering. Video presentation		No Presential	00:00	8%	4 / 10	CT.02 CG03 CT.01 CB08

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
16	Deliverable 1.CPS Analysis. Report		Face-to-face	00:00	35%	5 / 10	CG04 CB07 CB08 CE.04 CG03 CT.01 CE.13
16	Deliverable 2: CPS Design and implementation. Report		Face-to-face	00:00	30%	5 / 10	CG04 CB07 CB08 CE.04 CG03 CT.01 CE.13
16	Deliverable 3: CPS MDD enginering. Report		Face-to-face	00:00	35%	5 / 10	CG04 CB07 CT.02 CE.04 CG03 CT.01 CE.13

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Deliverable: CPS Analysis		Face-to-face	00:00	35%	5 / 10	CG04 CB07 CB08 CG03 CT.01 CE.13
Deliverable: CPS design, architecture, and implementation		Face-to-face	00:00	30%	5 / 10	CG04 CB07 CB08 CE.04 CG03 CT.01 CE.13

Deliverable: CPS MDD engineering		Face-to-face	00:00	35%	5 / 10	CG04 CB07 CB08 CE.04 CG03 CT.01 CE.13

7.2. Assessment criteria

CONTINUOUS ASSESSMENT GRADING

Assessment will evaluate the level of apprenticeship concerning skills and learning outcomes.

- Deliverable 1 (1.1 and 1.2): CPS Analysis (RA14)
- Deliverable 2 (1.1 and 1.2): CPS Design, Architecture and implementation (RA14, RA15, RA16)
- Deliverable 3 (1.1 and 1.2): CPS MDD engineering (RA14, RA15, RA16):

- Students will have to team up to produce deliverables (continuous assessment)

- Pass threshold (grading):
- Deliverable 1 (1.1 and 1.2): CPS Analysis: 4
- Deliverable 2 (1.1 and 1.2): CPS Design, Architecture and implementation: 4
- Deliverable 3 (1.1 and 1.2): CPS MDD engineering: 4

- Final Grading formula= (Deliverable1.1 * 30% + Deliverable 1.2 * 5%) + (Deliverable 2.1 * 25% + Deliverable 2.2 * 5%) + (Deliverable 3.1 * 30% + Deliverable 3.2 * 5%)

ONE EXAM ASSESSMENTs ("solo examen final") and EXTRA EXAM

Assessment will evaluate the level of apprenticeship concerning skills and learning outcomes.

- Deliverable 1: CPS Analysis(RA14)
- Deliverable 2: CPS Design, Architecture and implementation (RA14, RA15, RA16)
- Deliverable 3: CPS MDD engineering (RA14, RA15, RA16):

- Pass threshold (grading):

- Deliverable 1: CPS Analysis: 5
- Deliverable 2: CPS Design, Architecture and implementation: 5
- Deliverable 3: CPS MDD engineering: 5

- Final Grading formula= Deliverable1 * 35% + Deliverable2 * 30% + Deliverable3 * 35%

Those students that choose the option of "one exam" (solo examen final) will have to make an oral presentation of the deliverables produced and they will receive questions related to the material produced and in relation with any of the skills and learning outcomes of the course

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Guide to Computing Fundamentals in Cyber-Physical Systems	Bibliography	Dietmar P.F. Möller, Guide to Computing Fundamentals in Cyber-Physical Systems: Concepts, Design Methods, and Applications, Computer Communications and Networks, Springer, 1617-7975, 2016
Cyber-Physical Systems	Bibliography	Ragunathan (Raj) Rajkumar, Dionisio de Niz, Mark H. Klein, Cyber-Physical Systems (SEI Series in Software Engineering), Addison-Wesley, January 2017.
A Practical Guide to SysML: Systems Modeling Language	Bibliography	Sanford Friedenthal, Alan Moore, and Rick Steiner. 2008. A Practical Guide to SysML: Systems Modeling Language. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.
SysML Distilled: A Brief Guide to the Systems Modeling Language	Bibliography	Lenny Delligatti. 2013. SysML Distilled: A Brief Guide to the Systems Modeling Language (1st ed.). Addison-Wesley Professional.
SYSML	Web resource	http://www.omgsysml.org/
Model- Driven Software Development	Bibliography	Beydeda, S., Book, M. & Gruhn V., Model- Driven Software Development, Springer, 2005.
MDA Explained The Model Driven Architecture: Practice and Promise	Bibliography	Kleppe A., Warmer J., Bast W., MDA Explained The Model Driven Architecture: Practice and Promise, Addison Wesley, Object Technology Series, Grady Booch, Ivar

		Jacobson, and James Rumbaugh, 2004.
Software Factories	Bibliography	Greenfield J., Short K, Cook S., and Kent S, Software Factories, Wiley Publising Inc., 2004.
Specific Modeling: Enabling Full Code Generation	Bibliography	Kelly, S. and Tolvanen, J.-P., Domain- Specific Modeling: Enabling Full Code Generation, John Wiley & Sons, New Jersey. ISBN 978-0-470-03666-2, 2008
Moodle	Web resource	Moodle platform with all the resources of the course.
Architecting Principles for Systems-of-Systems	Bibliography	Maier, M. (1998). Architecting Principles for Systems-of-Systems. Systems Engineering, 1(4), 267?284. https://doi.org/10.1002/(SICI)1520-6858(1998)1:4<267::AID-SYS3>3.0.CO;2-D
System-of-Systems Engineering: A Definition	Bibliography	[2] Mo Jamshidi, System-of-Systems Engineering ? A Definition, IEEE SMC 2005, Big Island, Hawaii
Systems of Systems Engineering - Principles and Applications	Bibliography	Jamshidi, M. (ed.) 2009. Systems of Systems Engineering - Principles and Applications. Boca Raton, FL, USA: CRC Press.
The Past, Present and Future of Cyber-Physical Systems: A Focus on Models	Bibliography	Lee, E., & A., E. (2015). The Past, Present and Future of Cyber-Physical Systems: A Focus on Models. Sensors, 15(3), 4837?4869. https://doi.org/10.3390/s150304837
Requirements engineering for systems of systems	Bibliography	Lewis, G., Morris, E., Place, P., Simanta, S., & Smith, D. (2009). Requirements engineering for systems of systems. In IEEE Systems Conference (SysCon) (pp. 247?252). IEEE. https://doi.org/10.1109/SYSTEMS.2009.4815806

Taxonomy of Systems-of-Systems	Bibliography	Gideon, J., Dagli, C., & Miller, A. (2005). Taxonomy of Systems-of-Systems. In Systems Engineering Research.
SysML executable systems of system architecture definition: A working example	Bibliography	Dahmann, J. et al (2017). SysML executable systems of system architecture definition: A working example. 11th Annual IEEE International Systems Conference, SysCon https://doi.org/10.1109/SYSCON.2017.7934816
Cyber-Physical Systems	Web resource	http://www.cpse-labs.eu/cps.php
Cyber-Physical systems NIST Laboratory	Web resource	https://www.nist.gov/el/cyber-physical-systems

9. Other information

9.1. Other information about the subject

This course is related to SDG 9 "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation".

The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.