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

2019/20 - Semester 1

Index

Learning guide

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	2019-20

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. Se publicarán en la Web de la ETSISI y en el Moodle de la Asignatura.
Juan Garbajosa Sopeña (Subject coordinator)	1205	juan.garbajosa@upm.es	Sin horario. Se publicarán en la Web de la ETSISI y en el Moodle de la Asignatura.

Jenifer Perez Benedi	1203	jenifer.perez@upm.es	Sin horario. Se publicarán en la Web de la ETSISI y en el Moodle de la Asignatura.

* 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

- It is recommended previous knowledge about software modeling based on object-oriented paradigm, such as using UML diagrams.

- It is recommended previous knowledge about databases.

- It is recommended previous 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

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

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

* 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 development. Cyber-Physical Systems (CPS), according to NIST, comprise interacting digital, analogue, physical, and human components engineered for function through integrated physics and logic. CPS is heavily system-based, and therefore, complementary to the view provided by IoT. The approaches addressed in the course for the development of systems are Model Driven Development (MDD) and Model Driven Architecture (MDA) . The target systems are complex CPSs, those described as Systems of Systems. Tools to support MDA and MDD are introduced to students. Services, cloud, microservices and containers are introduced as elements for CPS implementation.

5.2. Syllabus

1. 1. Introduction to Cyber-Physical Systems (CPS)
    1.1. Internet of Things (IoT) and Cyber-Physical Systems (CPS)
    1.2. Systems of Systems (SoS)
    1.3. CPS and IoT Domains
2. Cyber-Physical Systems Development: Challenges and Approaches
3. Software/System architectures for Cyber-physical and IoT systems
4. Analysis, Specification and Design of Cyber-physical and IoT systems with modeling languages
5. Implementation of Cyber-Physical and IoT systems
    5.1. Introduction
    5.2. Services, Containers, Cloud, Microservices
6. Model Driven Development (MDD) Engineering for CPS and IoT
    6.1. MDD / MDA (Model Driven Development / Model Driven Architecture)
    6.2. Development of CPS and IoT using an MDD approach

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Other face-to-face activities	Assessment activities
1	**Presentation Lesson** Duration: 01:00 **Lesson 1: Introduction** Duration: 02:30			
2	**Lesson 1: Introduction** Duration: 01:00 **Lesson 2: Development Approaches** Duration: 02:30			
3	**Lesson 3: Software Architectures** Duration: 04:00		**Lesson 3: Software Architectures** Duration: 03:00	
4	**Lesson 4: Modeling** Duration: 01:30	**Lesson 4: Modeling** Duration: 02:00		
5			**CyberPhysical Systems Presentations** Duration: 03:30	**Deliverable: Cyberphysical Systems Analysis** Continuous assessment Duration: 00:00
6	**Lesson 4: Modeling** Duration: 02:00	**Lesson 4: Modeling** Duration: 05:00		
7		**Lesson 4: Modeling** Duration: 03:30		
8	**Lesson 5: Implementation** Duration: 03:30			**Deliverable: CPS Modeling** Continuous assessment Duration: 00:00
9	**Tema 6: MDD** Duration: 03:30	**Tema 6: MDD** Duration: 03:30		
10		**Tema 6:MDD** Duration: 03:30		

11			**MDD Presentations** Duration: 03:30	**Deliverable: MDD Development** Continuous assessment Duration: 00:00
12				
13				
14				
15				
16				**Deliverable: CPS Modeling** Final examination Duration: 00:00 **Deliverable: MDD Development** Final examination Duration: 00:00 **Deliverable: Cyberphysical Systems Analysis** Final examination Duration: 00:00
17				

The independent study hours are training activities during which students should spend time on individual study or individual assignments.

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 subject schedule is based on a previous theorical planning of the subject plan and might go to through experience some unexpected changes along throughout the academic year.

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: Cyberphysical Systems Analysis		Face-to-face	00:00	50%	5 / 10	CG04 CG03 CB07 CB08 CT.01 CE.13
8	Deliverable: CPS Modeling		Face-to-face	00:00	25%	4 / 10	CB07 CB08 CG04 CE.04 CG03 CT.01 CE.13
11	Deliverable: MDD Development		Face-to-face	00:00	25%	4 / 10	CG04 CE.04 CG03 CT.01 CE.13 CB07 CB08

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
16	Deliverable: CPS Modeling		Face-to-face	00:00	25%	5 / 10	CB08 CE.04 CG03 CT.01 CE.13 CG04 CB07
16	Deliverable: MDD Development		Face-to-face	00:00	25%	5 / 10	CE.04 CG03 CT.01 CB08 CE.13 CG04 CB07

16	Deliverable: Cyberphysical Systems Analysis		Face-to-face	00:00	50%	5 / 10	CE.04 CG03 CT.01 CE.13 CG04 CB07

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Deliverable: CPS Modeling		Face-to-face	00:00	25%	5 / 10	CG04 CG03 CT.01 CE.13 CB07 CB08
Deliverable: MDD Development		Face-to-face	00:00	25%	5 / 10	CB07 CB08 CG04 CE.04 CG03 CT.01 CE.13
Deliverable: Cyberphysical Systems Analysis		Face-to-face	00:00	50%	5 / 10	CB08 CG04 CE.04 CG03 CT.01 CE.13 CB07

7.2. Assessment criteria

CONTINUOUS ASSESSMENT GRADING

Elements under evaluation:
- Theoretical concepts. This part weights 50% in the final grading of the course.
- Deliverable 1: Cyberphysical Systems Analysis (RA14)
- Practicum: This part weights 50% of the final grading of the course. Two lab assignments must be conducted and their corresponding deliverables submitted.
- Deliverable 2: CPS Modeling (RA14, RA15, RA16): 25%
- Deliverable 3: MDD Development (RA14, RA15, RA16): 25%

- Requirements:
- Working in groups
- Threshold marks (for estimating average):
- Deliverable 1: Cyberphysical Systems Analysis: 5
- Deliverable 2: CPS Modeling: 4
- Deliverable 3: MDD Development: 4

- Final Grading formula= Deliverable1 * 50% + Deliverable2 * 25% + Deliverable3 * 25%

Students under continuous assessment have to make two presentations (Cyberphisical Systems Presentations and MDD Presentation). These presentations will be assessed and the grading of deliverable 1 (10%) and deliverable 3 (10%) will include the presentation and how students will snaswer the questions that students will be made.

FINAL/EXTRAORDINARY ASSESSMENT

- Elements under evaluation:
- Theoretical concepts. This part weights 50% in the final grading of the course.
- Deliverable 1: Cyberphysical Systems Analysis (RA14)
- Practicum: This part is weighted with 50% of the final grading of the course. Two lab assignments must be conducted and their corresponding deliverables submitted.

- Deliverable 2: CPS Modeling (RA14, RA15, RA16): 25%
- Deliverable 3: MDD Development (RA14, RA15, RA16): 25%

- Requirements:
  - Working Individually
  - Threshold marks for the average:
  - Deliverable 1: Cyberphysical Systems Analysis: 5
  - Deliverable 2: CPS Modeling: 5
  - Deliverable 3: MDD Development: 5

- Final Grading formula= Deliverable1 * 50% + Deliverable2 * 25% + Deliverable3 * 25%

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 " and , partly related to SDG 6 "Ensure access to affordable, reliable, sustainable and modern energy for all", SDG 7 "Ensure access to affordable, reliable, sustainable and modern energy for all ", and SDG 11 "Make cities and human settlements inclusive, safe, resilient and sustainable". Some others may also benefit from useful and solid CPSs.