

**1. General information****Course:** HYDROGEN TECHNOLOGY AND FUEL CELLS**Type:** ELECTIVE**Degree:** 420 - UNDERGRADUATE DEGREE PROGRAMME IN MECHANICAL ENGINEERING**Center:** 605 - SCHOOL OF INDUSTRIAL ENGINEERS. AB**Year:** 4**Main language:** English**Use of additional languages:****Web site:****Code:** 56338**ECTS credits:** 6**Academic year:** 2023-24**Group(s):** 11**Duration:** First semester**Second language:** English**English Friendly:** N**Bilingual:** N**Lecturer:** JESUS CANALES VAZQUEZ - Group(s): 11

Building/Office	Department	Phone number	Email	Office hours
Instituto Energías Renovables/OD1	MECÁNICA ADA. E ING. PROYECTOS	926053197	jesus.canales@uclm.es	

2. Pre-Requisites

Not established

3. Justification in the curriculum, relation to other subjects and to the profession

Not established

4. Degree competences achieved in this course**Course competences**

Code	Description
CB01	Prove that they have acquired and understood knowledge in a subject area that derives from general secondary education and is appropriate to a level based on advanced course books, and includes updated and cutting-edge aspects of their field of knowledge.
CB02	Apply their knowledge to their job or vocation in a professional manner and show that they have the competences to construct and justify arguments and solve problems within their subject area.
CB03	Be able to gather and process relevant information (usually within their subject area) to give opinions, including reflections on relevant social, scientific or ethical issues.
CB04	Transmit information, ideas, problems and solutions for both specialist and non-specialist audiences.
CB05	Have developed the necessary learning abilities to carry on studying autonomously
CEO14	Acquisition of applied knowledge of energy saving and efficiency.
CG01	Ability to draft, sign and develop projects in the field of Industrial Engineering, in accordance with the knowledge acquired under the provisions of Order CIN/351/2009, for the construction, reform, repair, conservation, demolition, manufacture, installation, assembly or operation of: structures, mechanical equipment, energy installations, electrical and electronic installations, industrial installations and plants, and manufacturing and automation processes.
CG02	Ability to manage activities related to engineering projects in the field of industrial engineering.
CG04	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.
CT02	Knowledge and application of information and communication technology.
CT03	Ability to communicate correctly in both spoken and written form.

5. Objectives or Learning Outcomes**Course learning outcomes**

Description

Reasoning of applicable hydrogen utilisation technologies and their use in fuel cells. Power generation and propulsion applications.

Additional outcomes**6. Units / Contents****Unit 1: Introduction to Hydrogen Technology & Fuel Cells****Unit 1.1** Context: Hydrogen as Energy Vector**Unit 1.2** Distributed Generation**Unit 1.3** Batteries**Unit 1.4** Application of Primary and Secondary Batteries**Unit 2: Hydrogen****Unit 2.1** Physicochemical Properties**Unit 2.2** Hydrogen Production: Reforming, Electrolysis, Thermochemical Cycles, Photoelectrochemical**Unit 2.3** Storage and Distribution**Unit 3: Fuel Cells****Unit 3.1** Introduction**Unit 3.2** Types of Fuel Cells

Unit 3.3 Triple Phase Boundaries and Electrode Processes

Unit 3.4 Thermodynamics

Unit 3.5 Fuel Cell Efficiency

Unit 4: Fuel Cell Applications

Unit 4.1 Fuel Cell Systems

Unit 4.2 Hybrid Systems Renewables-Fuel Cells

7. Activities, Units/Modules and Methodology

Training Activity	Methodology	Related Competences (only degrees before RD 822/2021)	ECTS	Hours	As	Com	Description
Class Attendance (theory) [ON-SITE]	Lectures	CB01 CB02 CB04	0.88	22	N	-	
Workshops or seminars [ON-SITE]	Problem solving and exercises	CB01 CB02 CB03 CB05	0.32	8	N	-	
Project or Topic Presentations [ON-SITE]	Reading and Analysis of Reviews and Articles	CB01 CB02 CB03 CB04	0.64	16	Y	N	
Writing of reports or projects [OFF-SITE]	Self-study	CB03 CB04 CB05	0.96	24	Y	N	
Laboratory practice or sessions [ON-SITE]	Practical or hands-on activities	CB01 CB02 CB03 CB05	0.32	8	Y	N	
Practicum and practical activities report writing or preparation [OFF-SITE]	Self-study	CB04 CB05	0.4	10	Y	N	
On-line debates and forums [OFF-SITE]	Online Forums	CB01 CB02 CB04	0.8	20	N	-	
Progress test [ON-SITE]	Assessment tests	CB01 CB04 CB05	0.16	4	Y	N	
Final test [ON-SITE]	Assessment tests	CB02 CB03 CB04	0.08	2	Y	N	
Study and Exam Preparation [OFF-SITE]	Self-study		1.44	36	N	-	
Total:			6	150			
Total credits of in-class work: 2.4			Total class time hours: 60				
Total credits of out of class work: 3.6			Total hours of out of class work: 90				

As: Assessable training activity

Com: Training activity of compulsory overcoming (It will be essential to overcome both continuous and non-continuous assessment).

8. Evaluation criteria and Grading System

Evaluation System	Continuous assessment	Non-continuous evaluation*	Description
Final test	0.00%	40.00%	
Oral presentations assessment	30.00%	30.00%	
Progress Tests	40.00%	0.00%	
Practicum and practical activities reports assessment	20.00%	20.00%	
Assessment of problem solving and/or case studies	10.00%	10.00%	
Total:	100.00%	100.00%	

According to art. 4 of the UCLM Student Evaluation Regulations, it must be provided to students who cannot regularly attend face-to-face training activities the passing of the subject, having the right (art. 12.2) to be globally graded, in 2 annual calls per subject, an ordinary and an extraordinary one (evaluating 100% of the competences).

9. Assignments, course calendar and important dates

Not related to the syllabus/contents	
Hours	hours
Final test [PRESENCIAL][Assessment tests]	2
Study and Exam Preparation [AUTÓNOMA][Self-study]	10
Unit 1 (de 4): Introduction to Hydrogen Technology & Fuel Cells	
Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	6
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	4
Project or Topic Presentations [PRESENCIAL][Reading and Analysis of Reviews and Articles]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	6
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	1
Practicum and practical activities report writing or preparation [AUTÓNOMA][Self-study]	2
On-line debates and forums [AUTÓNOMA][Online Forums]	4
Progress test [PRESENCIAL][Assessment tests]	1
Study and Exam Preparation [AUTÓNOMA][Self-study]	8
Unit 2 (de 4): Hydrogen	
Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	6
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	2

Project or Topic Presentations [PRESENCIAL][Reading and Analysis of Reviews and Articles]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	6
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	1
Practicum and practical activities report writing or preparation [AUTÓNOMA][Self-study]	4
On-line debates and forums [AUTÓNOMA][Online Forums]	6
Progress test [PRESENCIAL][Assessment tests]	1
Study and Exam Preparation [AUTÓNOMA][Self-study]	10
Unit 3 (de 4): Fuel Cells	
Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	6
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	2
Project or Topic Presentations [PRESENCIAL][Reading and Analysis of Reviews and Articles]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	6
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	4
Practicum and practical activities report writing or preparation [AUTÓNOMA][Self-study]	4
On-line debates and forums [AUTÓNOMA][Online Forums]	4
Progress test [PRESENCIAL][Assessment tests]	1
Study and Exam Preparation [AUTÓNOMA][Self-study]	8
Unit 4 (de 4): Fuel Cell Applications	
Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2
Project or Topic Presentations [PRESENCIAL][Reading and Analysis of Reviews and Articles]	2
Writing of reports or projects [AUTÓNOMA][Self-study]	6
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	2
On-line debates and forums [AUTÓNOMA][Online Forums]	6
Progress test [PRESENCIAL][Assessment tests]	1
Study and Exam Preparation [AUTÓNOMA][Self-study]	10
Global activity	
Activities	hours
Workshops or seminars [PRESENCIAL][Problem solving and exercises]	8
Project or Topic Presentations [PRESENCIAL][Reading and Analysis of Reviews and Articles]	8
Class Attendance (theory) [PRESENCIAL][Lectures]	20
Writing of reports or projects [AUTÓNOMA][Self-study]	24
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	8
Practicum and practical activities report writing or preparation [AUTÓNOMA][Self-study]	10
On-line debates and forums [AUTÓNOMA][Online Forums]	20
Progress test [PRESENCIAL][Assessment tests]	4
Final test [PRESENCIAL][Assessment tests]	2
Study and Exam Preparation [AUTÓNOMA][Self-study]	46
Total horas: 150	

10. Bibliography and Sources						
Author(s)	Title/Link	Publishing house	Citv	ISBN	Year	Description
	Centro Nacional del Hidrógeno y Pilas de Combustible www.cnethpc.es					Página web
	Plataforma Española del Hidrógeno y Pilas de Combustible www.ptehpc.org					Página web
A. Züttel, A. Borgschulte and L. Schlapbach	Hydrogen as a Future Energy Carrier	Wiley & Sons			2008	
D. Linden	Handbook of Batteries	McGraw Hill			2019	
E.G. Technical Services Inc.	Fuel Cell Handbook http://www.osti.gov/bridge/servlets/purl/834188/834188.pdf	U.S. Department of Energy			2004	
D. Stolten & B Emons	Hydrogen Science and Engineering : Materials, Processes, Systems and Technology	Wiley		9783527332380	2016	
J. Canales-Vázquez & J.C. Ruiz-Morales	Fuel Cells in "Materials for Sustainable Energy Applications. Conversion, Storage, Transmission and Consumption"	Pan Stanford Publishing		9789814411813	2016	
A. León	Hydrogen Technology	Springer		978-3-642-09785-0	2008	
J. Larminie and A. Dicks	Fuel Cells Systems Explained	John Wiley & Sons			2003	
R. O'Hayre, S-W. Cha, W. Colella and F.B. Prinz	Fuel Cell Fundamentals	Wiley & Sons		978-0-470-25843-9	2009	
S. Supramaniam	Fuel Cells: From Fundamentals to Applications	Springerlink (1st Edition)			2006	
Varios Autores	Pilas de Combustible de Óxido	CCPC (2ª		978-84-7926-567-0	2008	

	Sólido Asociación Española del Hidrógeno www.aeh2.org	Edición)		Página web
VVAA	Energía: Desarrollos Tecnológicos en la Protección Medioambiental	Thomson Reuters	978-84-470-3806-0	2011