

**1. General information****Course:** HYDROGEN TECHNOLOGY AND FUEL CELLS**Type:** ELECTIVE**Degree:** 352 - UNDERGRADUATE DEGREE PROGRAMME IN MECHANICAL ENGINEERING (AB)**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

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**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
A04	To be able to transmit information, ideas, problems and solutions to a specialized audience.
A08	Appropriate level of oral and written communication.
A10	Ability to produce and develop projects in the field of industrial engineering and automation aimed at, and in accordance with the knowledge acquired as established in section 5 of Order CIN/351/2009, the construction, remodelling, repair, conservation, demolition, manufacturing, installation, assembly or use of: structures, mechanical equipment, power installations, electrical and electronic installations, industrial plants and installations and processes of manufacture and automatization.
A11	Ability to manage engineering project activities described in the previous competency.
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
F14	Acquisition of applied knowledge of energy saving and efficiency.
F15	Be familiar with the basic concepts of the capture, conversion and use of the sources of renewable energy and their application to the generation of electricity or use in heating/cooling systems.

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

Description

Explain the applicable technologies for the use of hydrogen and its use in fuel cells. Applications of electrical generation and propulsion

**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	A10 CB01 CB02 CB04 F14 F15	0.88	22	N	-	
Workshops or seminars [ON-SITE]	Problem solving and exercises	A10 CB01 CB02 CB03 CB05 F15	0.32	8	N	-	
Project or Topic Presentations [ON-SITE]	Reading and Analysis of Reviews and Articles	CB01 CB02 CB03 CB04 F14 F15	0.64	16	Y	N	
Writing of reports or projects [OFF-SITE]	Self-study	A10 A11 CB03 CB04 CB05 F14 F15	0.96	24	Y	N	
Laboratory practice or sessions [ON-SITE]	Practical or hands-on activities	CB01 CB02 CB03 CB05 F14 F15	0.32	8	Y	N	
Practicum and practical activities report writing or preparation [OFF-SITE]	Self-study	A10 CB04 CB05	0.4	10	Y	N	
On-line debates and forums [OFF-SITE]	Online Forums	CB01 CB02 CB04 F14 F15	0.8	20	N	-	
Progress test [ON-SITE]	Assessment tests	CB01 CB04 CB05 F14 F15	0.16	4	Y	N	
Final test [ON-SITE]	Assessment tests	CB02 CB03 CB04 F14 F15	0.08	2	Y	N	
Study and Exam Preparation [OFF-SITE]	Self-study	F14 F15	1.44	36	N	-	
<b>Total:</b>			<b>6</b>	<b>150</b>			
<b>Total credits of in-class work: 2.4</b>			<b>Total class time hours: 60</b>				
<b>Total credits of out of class work: 3.6</b>			<b>Total hours of out of class work: 90</b>				

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%	
<b>Total:</b>	<b>100.00%</b>	<b>100.00%</b>	

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**

<b>Not related to the syllabus/contents</b>	
<b>Hours</b>	<b>hours</b>
Final test [PRESENCIAL][Assessment tests]	2
Study and Exam Preparation [AUTÓNOMA][Self-study]	10
<b>Unit 1 (de 4): Introduction to Hydrogen Technology &amp; Fuel Cells</b>	
<b>Activities</b>	<b>Hours</b>
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
<b>Unit 2 (de 4): Hydrogen</b>	
<b>Activities</b>	<b>Hours</b>
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
<b>Unit 3 (de 4): Fuel Cells</b>	
<b>Activities</b>	<b>Hours</b>
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
<b>Unit 4 (de 4): Fuel Cell Applications</b>	
<b>Activities</b>	<b>Hours</b>
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
<b>Global activity</b>	
<b>Activities</b>	<b>hours</b>
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
<b>Total horas: 150</b>	

10. Bibliography and Sources						
Author(s)	Title/Link	Publishing house	Citv	ISBN	Year	Description
	Centro Nacional del Hidrógeno y Pilas de Combustible <a href="http://www.cnehtpc.es">www.cnehtpc.es</a>					Página web
	Plataforma Española del Hidrógeno y Pilas de Combustible <a href="http://www.ptehpc.org">www.ptehpc.org</a>					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 <a href="http://www.osti.gov/bridge/servlets/purl/834188/834188.pdf">http://www.osti.gov/bridge/servlets/purl/834188/834188.pdf</a>	U.S. Department of Energy			2004	
D. Stolten & B Emonts	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 Sólido Asociación Española del Hidrógeno www.aeh2.org	CCPC (2ª Edición)	978-84-7926-567-0	2008	Página web
VVAA	Energía: Desarrollos Tecnológicos en la Protección Medioambiental	Thomson Reuters	978-84-470-3806-0	2011	