



POLITÉCNICA

INTERNATIONAL  
CAMPUS OF  
EXCELLENCE

COORDINATION PROCESS OF  
LEARNING ACTIVITIES  
PR/CL/001



E.T.S. de Ingenieros de  
Caminos, Canales y Puertos

# ANX-PR/CL/001-01

## LEARNING GUIDE

### SUBJECT

**43000616 - Electroquímica Para Aplicaciones En Energía**

### DEGREE PROGRAMME

04AN - Master Universitario En Ingenieria De Materiales

### ACADEMIC YEAR & SEMESTER

2023/24 - Semester 2

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## 1. Description

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### 1.1. Subject details

<b>Name of the subject</b>	43000616 - Electroquímica para Aplicaciones en Energía
<b>No of credits</b>	3 ECTS
<b>Type</b>	Optional
<b>Academic year of the programme</b>	First year
<b>Semester of tuition</b>	Semester 2
<b>Tuition period</b>	February-June
<b>Tuition languages</b>	English
<b>Degree programme</b>	04AN - Master Universitario en Ingeniería de Materiales
<b>Centre</b>	04 - Escuela Técnica Superior De Ingenieros De Caminos, Canales Y Puertos
<b>Academic year</b>	2023-24

## 2. Faculty

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### 2.1. Faculty members with subject teaching role

<b>Name and surname</b>	<b>Office/Room</b>	<b>Email</b>	<b>Tutoring hours *</b>
Fco. Javier Llorca Martínez (Subject coordinator)		javier.llorca@upm.es	- -

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

## 2.3. External faculty

Name and surname	Email	Institution
Moumita Rana	rana.moumita@gmail.com	Delft University of Technology

## 3. Prior knowledge recommended to take the subject

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### 3.1. Recommended (passed) subjects

- Materials For Energy

### 3.2. Other recommended learning outcomes

- basic electrochemistry

## 4. Skills and learning outcomes \*

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### 4.1. Skills to be learned

CE1 - Capacidad para aplicar los fundamentos científicos del comportamiento físico y químico de los materiales para relacionar causalmente sus propiedades fundamentales físicas y químicas con su comportamiento macroscópico y el de los productos con ellos realizados / Ability to apply the scientific foundations of the physical and chemical behavior of materials to correlate their fundamental physical and chemical properties with their macroscopic behavior and that of the products made with them.

CE2 - Uso de equipos y técnicas experimentales de caracterización de materiales (micro y macroestructura, comportamientos mecánico, eléctrico, y óptico) para identificar y analizar los diversos tipos de materiales / Use of equipment and experimental techniques for the characterization of materials (micro and macrostructure, mechanical, electrical, and optical behavior) to identify and analyze the various types of materials.

CE5 - Capacidad para planificar, explotar y gestionar técnicamente la selección, fabricación, procesado, utilización, reciclado, reutilización y eliminación de materiales, de forma respetuosa con el medio ambiente, de conformidad con la legislación nacional e internacional, y promoviendo el desarrollo sostenible y el bienestar de la sociedad / Ability to technically plan, exploit and manage the selection, manufacturing, processing, use, recycling, reuse and disposal of materials, in an environmentally friendly manner, in accordance with national and international legislation, and promoting sustainable development and well-being of the society

CG1 - Uso de la lengua inglesa: Los alumnos son capaces de transmitir conocimientos y expresar ideas y argumentos de manera clara, rigurosa y convincente, tanto de forma oral como escrita, adaptándose a las características de la situación y de la audiencia / Use of the English Language: Students are able to transmit knowledge and express ideas and arguments in a clear, rigorous and convincing manner, both orally and in writing, adapting to the characteristics of the situation and the audience .

CG3 - Trabajo en equipo: Los alumnos desarrollan la capacidad para trabajar en equipo, integrarse y colaborar de forma activa en la consecución de objetivos comunes / Teamwork: Students develop the ability to work as a team, integrate and actively collaborate in achieving common goals.

CG4 - Creatividad: Los alumnos son capaces de resolver de forma nueva, original y aportando valor, situaciones o problemas en el ámbito de la ingeniería de materiales / Creativity: Students are able to solve situations or problems in the field of materials engineering in a new, original way and adding value.

CG5 - Organización y planificación: Los estudiantes son capaces de fijar objetivos, con la planificación y programación de actividades (tiempo y fases) y con la organización y gestión de los recursos necesarios para alcanzarlos / Organization and Planning: Students are capable of setting objectives, with the planning and programming of activities (time and phases) and with the organization and management of the necessary resources to achieve them..

CG8 - Resolución de problemas: Los estudiantes son capaces de reconocer, describir, organizar y analizar los elementos constitutivos de un problema para idear estrategias que permitan obtener, de forma razonada, una solución contrastada y acorde a ciertos criterios preestablecidos / Problem solving: Students are able to recognize, describe, organize and analyze the constitutive elements of a problem to devise strategies that allow obtaining, in a reasoned way, a contrasting solution and according to certain pre-established criteria.

## 4.2. Learning outcomes

RA10 - basic and advanced knowledge on electrochemical techniques, photo-electrochemistry and electrochemical energy storage devices

\* 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

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### 5.1. Brief description of the subject

This subject provides basic and advanced knowledge on electrochemical techniques, photo-electrochemistry and electrochemical energy storage devices

### 5.2. Syllabus

1. Introduction to electrochemical cells: history, figures of merit and used.
2. Electrochemical techniques
3. Electrocatalytic cells
4. Photoelectrochemical cells
5. Batteries
6. Capacitors
7. Hybrid energy storage devices

## 6. Schedule

### 6.1. Subject schedule\*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	<b>Tema 1: Introduction to electrochemical cells</b> Duration: 01:00  <b>Tema 2: Electrochemical techniques</b> Duration: 01:00			
2	<b>Electrochemical techniques</b> Duration: 02:00			
3	<b>Tema 3: Electrocatalytic cells</b> Duration: 02:00			<b>Solution of exercises</b>  Continuous assessment Presential Duration: 01:00
4	<b>Tema 3: Electrocatalytic cells</b> Duration: 02:00			
5	<b>Tema 4: Photoelectrochemical cells</b> Duration: 02:00			<b>Solution of exercises</b>  Continuous assessment Presential Duration: 01:00
6	<b>Tema 4: Photoelectrochemical cells</b> Duration: 02:00			
7	<b>Tema 4: Photoelectrochemical cells</b> Duration: 02:00			<b>Solution of exercises</b>  Continuous assessment Presential Duration: 01:00
8	<b>Tema 5. Batteries</b> Duration: 02:00			
9	<b>Tema 5. Batteries</b> Duration: 02:00			<b>Solution of exercises</b>  Continuous assessment Presential Duration: 01:00
10	<b>Tema 5. Batteries</b> Duration: 02:00			

11	<b>Tema 6.Capacitors</b> Duration: 02:00			<b>Solution of exercises</b>  Continuous assessment Presential Duration: 01:00
12	<b>Tema 7. Hybrid energy storage devices</b> Duration: 02:00			
13	<b>Laboratories</b> Duration: 02:00			
14	<b>Laboratories</b> Duration: 02:00			
15				<b>Evaluación</b>  Final examination Not Presential Duration: 03:00
16				
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. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
3	Solution of exercises		Face-to-face	01:00	20%	5 / 10	CG1 CG4 CG5 CG8 CE1
5	Solution of exercises		Face-to-face	01:00	20%	5 / 10	CG1 CG4 CG5 CG8 CE1 CE2 CE5
7	Solution of exercises		Face-to-face	01:00	20%	5 / 10	CG1 CG4 CG5 CG8 CE1 CE2 CE5
9	Solution of exercises		Face-to-face	01:00	20%	5 / 10	CG1 CG3 CG4 CG5 CG8 CE1 CE2
11	Solution of exercises		Face-to-face	01:00	20%	5 / 10	CG1 CG4 CG5 CG8 CE1 CE2 CE5

#### 7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
15	Evaluación		No Presential	03:00	100%	5 / 10	CG1 CG4 CG5 CG8 CE1 CE5

### 7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

## 7.2. Assessment criteria

Attendance to laboratory practices is mandatory to have access to the final ordinary exam

The minimum average score in the final exam has to be equal or higher than 50%

## 8. Teaching resources

### 8.1. Teaching resources for the subject

Name	Type	Notes
Allen J. Bard ? Electrochemical Methods: Fundamentals and Application. Z-lib.org	Bibliography	
Handbook of batteries. Mc Graw Hill Professional (2001)	Bibliography	
Photoelectrochemistry: Principles and Practices, B. Viswanathan, M. Aulice Scibioh, ISBN-13: 978-1842657126	Bibliography	

Lithium-Ion Batteries: Science and Technologies, Yoshio, Masaki, Brodd, Ralph J., Kozawa, ISBN 978-0-387-34445-4	Bibliography	
Advanced Materials for Sodium Ion Storage, ISBN 9780429753015	Bibliography	
Magnesium Batteries: Research and Applications, ISBN-13: 978-1788014342	Bibliography	
Aluminium-ion batteries: developments and challenges, J. Mater. Chem. A, 2017,5, 6347-6367	Bibliography	
Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications, Brian Evans Conway, ISBN 978-1-4757-3058-6	Bibliography	
Metal-Ion Hybrid Capacitors for Energy Storage, ISBN 978-3-030-60812-5	Bibliography	