MEMBRANE PROCESSES FOR ENVIRONMENTAL SUSTAINABILITY

Teaching Unit	Membrane Processes for Environmental Sustainability	
Unit Code		
Degree title (CdS)	ENVIRONMENTAL AND TERRITORIAL SAFETY ENGINEERING	
Degree level	II	
Module code		
Scientific Disciplinary Sector (SSD)	CHIM/07	
Number of ECTS credits (CFU)	6	
Teaching Unit Category (TAF)	A	
Teaching Unit Qualification		
Course year	II	
Semester	I	
Lecturer	Efrem Curcio	
Other instructors involved	none	
Module breakdown	Hours of Lectures	36
	Hours of Practicals	12
	Hours of Laboratory	
	Hours of Individual study	102
Language	English	
Mandatory prerequisites	none	
Prerequisites	Basic know-how on membrane separation technology and principles of sustainability.	
Content	The course aims to provide the student with the advanced knowledge and design tools on membrane separation and reaction technologies for sustainable energy applications and eco-friendly chemical production. Green Deal challenges will be addressed within a scientific framework based on energetic transition and low-carbon technologies, circular economy and process intensification for a sustainable industrial development.	
Teaching objectives	*Specific competences* • Theoretical and operational skills on polymeric, metallic and ceramic membranes for selective separation of hydrogen and oxygen and carbon dioxide; • Theoretical and operational skills on high-temperature membrane separation and reaction applied to hydrogen production from different sources according to the principles of Process Intensification; • theoretical and operational skills on membrane-based technologies for water splitting, membrane technology in biogas, bioethanol and biodiesel production. *Transversal competences (soft-skills)*: • Problem-solving skills: ability to solve complex problems by applying the scientific method, capacity to address uncertainty; • bibliographic skills: autonomy in searching for information from	

	scientific literature, team working; • communication skills: ability to resume information from different sources, adoption of a clear and scientifically appropriate language.
Programme	***LESSONS*** **1. Metallic, ceramic and polymeric membranes for H_2, O_2 and CO_2 separation** 1.1 Palladium and Pd-alloy membranes for H_2 separation. 1.2 Perovskite and mixed ionic-electronic conducting (MIEC) membranes 1.3 CO_2-selective polymeric and Mixed matrix membranes **2. High temperature membrane reactors for H_2 production** 2.1 Membrane reactors for water gas shift 2.2 Membrane reactors for steam reforming of methane and glycerol 2.3 Membrane reactors for autothermal reforming of methane and methanol **3. Low temperature membrane systems for energy applications** 3.1 Electrochemical and photocatalytic membrane systems for water splitting 3.2 Membrane bioreactors and membrane separation for biogas production 3.3 Membrane systems for bioethanol recovery 3.4 Membrane reactors for transesterification ***PRACTICALS*** Physical and chemical adsorption. Sievert's Law. Fick's law. Solution-Diffusion model. Fundamentals of thermodynamics and kinetics in membrane reactors
Delivery Mode	Frontal teaching
Teaching Methods	Teacher-driven lessons according to the traditional model of classroom instruction. Main facilities: blackboard, slides. Students are encouraged to solve autonomously specific exercises, in order to stimulate their aptitude to problem-solving, cooperative learning and team work, using peer-reviewed scientific literature. Use of on-line platform in case of COVID-19 pandemic restrictions.
Methods and Criteria of Learning Assessment	*Student performance assessment methods:* The exam consists of: **1. Discussion of a written essay (typically 20-25 pages)** Previously prepared by the student in the form of a state-of-the-art review on a specific topic of the course; mark on a scale 0-30 will be assigned.

	2. Oral examination (duration of 20-30 minutes) Three questions related to the theoretical contents of the course with the aim to assess the knowledge of the topics; mark on a scale 0-30 will be assigned. *Criteria used in the students' performance assessment:* The final grade will be assigned on a scale 0-30, as an arithmetic average of both parts of the exam (essay and oral).
Textbooks and recommended reading	Reference material provided during the lessons
Peer review	Prof. Raffaele Molinari; Prof. Massimo Migliori
Teaching timetable	http://diam.unical.it
Examination calendar	http://diam.unical.it
Examinatory commission	http://diam.unical.it

ESTIMATED STUDENT WORKLOAD				
	Lectures [hours]	Praticals [hours]	Laboratory [hours]	Individual study [hours]
1. Metallic, ceramic and polymeric membranes for H_2, O_2 and CO_2 separation	12	4		24
2. High temperature membrane reactors for H_2 production	12	4		24
3. Low temperature membrane systems for energy applications	12	4		24
Hours dedicated to soft skills				6
Reports/other homeworks				
Additional hours dedicated to final exam preparation (essay preparation)				24
TOTAL	**36**	**12**		**102**
OVERALL NUMBER OF HOURS	✓ **150**			