University of Zagreb

1. GENERAL INFORMATION				
1.1 Course teacher	Prof. Zoran Mandić, PhD		1.6 Year of the study	2 (3rd semester)
1.2 Name of the course	Electrochemical Energy Storage and Conversion		1.7 ECTS credits	5
1.3 Associate teachers	Assist. Prof. Fabio Faraguna, PhD Roko Blažic, mag. ing. cheming.		1.8 Type of instruction (number of hours L + E + S + e-learning)	Total: 60 (L:30, E:15, S:15)
1.4 Study programme (undergraduate, graduate, integrated)	Graduate		1.9 Expected enrolment in the course	10
1.5. Status of the course	☐ mandatory	☒ elective	1.10 Level of application of e-learning (level 1, 2, 3), percentage of online instruction (max. 20%)	2

2. COUSE DESCRIPTION	
2.1. Course objectives	The goal of this course is to enable students to acquire the basic and applied knowledge, and to learn necessary skills to understand the role of electrochemical storage and energy conversion devices and their application in science, technology and industry. Students will also acquire knowledge of their operation and applications, design and development methodology of new devices and advanced materials.
2.2. Enrolment requirements and/or entry competences required for the course	
2.3. Learning outcomes at the level of the programme to which the course contributes	• Compile and apply advanced knowledge of natural and technical sciences, particularly chemical engineering and environmental engineering in solving scientific, professional and general social problems. • Solve engineering problems using the scientific method combining expert knowledge from chemistry, environmental, and chemical engineering as well as material science and engineering. • Correlate expert knowledge from chemistry, chemical engineering and material engineering with awareness of influence on society, economy and environment. • Plan and independently perform experiments in order to confirm a hypothesis to estimate economic and ecological efficiency of processes. • Independently organise and plan timelines, apply a general methodology for project planning and management in a business environment • Demonstrate independence and reliability in independent work, as well as effectiveness, reliability and adaptability in team work • Communicate with the scientific and professional community, as well as society in general in local and international surroundings • Develop work ethic, personal responsibility and tendency for further skill and knowledge acquisition, according to standards of engineering practice •

2.4. Expected learning outcomes at the level of the course (3 to 10 learning outcomes)	1. Define the scope of electrochemical technologies and their principles for use in electrochemical energy storage 2. Explain the electrochemical phenomena and processes that are the basis of the electrochemical energy conversion 3. Analyse the advantages and disadvantages of different types of electrochemical technologies 4. Design and setting up the experiments for testing and developing materials for the use in electrochemical energy conversion devices 5. Suggest different options and possibilities for solving the present energy and ecological problems 6. Apply acquired knowledge in practice in developing and modelling battery systems		
2.5. Course content (syllabus)	**WEEK 1.** Introduction to electrochemical energy conversion devices, types, historical review, and their role in solving energy and ecological problems **WEEK 2.** Physical-chemical and electrochemical principles of electrochemical energy converters. Thermodynamics of electrochemical converters and energy storage cells **WEEK 3.** Electrochemical kinetics, overvoltage and losses in electrochemical energy converters. Irreversibility of electrochemical reactions **WEEK 4.** Week: Galvanic cells. Types and working principles. **WEEK 5.** Rechargeable electrochemical cells. Lead-acid batteries, Ni/Cd, Ni/MH galvanic cells **WEEK 6.** Lithium batteries **WEEK 7.** Advanced materials and technology for battery design **WEEK 8.** Partial exam **WEEK 9.** Fuel cells, working principles, types, properties and applications (Part 1.) **WEEK 10.** Fuel cells, working principles, types, properties and applications (Part 2.) **WEEK 11.** Fuels for Fuel cells **WEEK 12.** Electrochemical capacitors. Principles and application. **WEEK 13.** Testing of and materials for electrochemical capacitors **WEEK 14.** Test and analysis of electrochemical energy devices. Determination of the state of charge and the state of health **WEEK 15.** Partial exam .		
2.6. Format of instruction:	☒ lectures ☒ seminars and workshops ☒ exercises ☐ online in entirety ☐ partial e-learning ☐ field work	☒ independent assignments ☐ multimedia and the internet ☒ laboratory ☐ work with mentor ☐ (other)	2.7. Comments:
2.8. Student responsibilities	Attendance to all forms of teaching is obligatory, at least 75%. Absence from the seminars and lab exercise must be compensated. Before passing the exam, the student is required to submit the written seminar report, complete all the exercises and submit all written reports.		

2.9. Monitoring student work	Class attendance	YES		Research		NO	Oral exam		NO
	Experimental work	YES		Report		NO	(other)		
	Essay		NO	Seminar paper	YES		(other)		
	Preliminary exam	YES		Practical work	YES		(other)		
	Project		NO	Written exam	YES		ECTS credits (total)	5	

	Title	Number of copies in the library	Availability via other media
2.10. Required literature (available in the library and/or via other media)	Teaching materials prepared by the course teachers for lectures, seminars and laboratory exercise.		www.fkit.unizg.hr
	A.J. Bard and L.R. Faulkner, Electrochemical methods, Fundamentals and applications, John Wiley & Sons, Inc., 2001, New Jersey	1	
	C.A. Vincent, B. Scrosati, Modern batteries, John Wiley & Sons, Inc., 1997, New Jersey	2	
2.11. Optional literature	B. Scrosati, J. Garche, Journal of Power Sources, 195 (2010) 2419-2430		
	S. Srinivasan, Fuel Cells From Fundamentals to Applications, Springer, 2003, New York		
	M. M. Mench, Fuel Cell Engines, John Wiley & Sons, Inc., 2008, New Jersey		
	B.E. Conway, Electrochemical supercapacitors, Scientific fundamentals and technological applications, Springer, 2002		
2.12. Other (as the proposer wishes to add)			