University of Zagreb

1. GENERAL INFORMATION				
1.1 Course teacher	Prof. Ante Jukić, PhD		1.6 Year of the study	1st (1st semester)
1.2 Name of the course	Applied Catalysis		1.7 ECTS credits	5.
1.3 Associate teachers	Assist. Prof. Fabio Faraguna, PhD Marin Kovačić, PhD Roko Blažic, mag. ing. cheming. Josipa Papac, mag. ing. oecoing.		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	20
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	Introducing students with basic industrial scale catalytic processes; synthesis and preparation of catalysts; characterization techniques; catalyst reaction mechanisms. Students will gain detailed process knowledge of industrial catalytic processes in oil refining, petrochemistry and wastewater treatment.
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. • Utilise advanced laboratory procedures and instruments for synthesis of new products, create sustainable processes, and solve problems of water, air and soil pollution. • Apply different analytical techniques, analytical and numerical methods, as well as software tools in creative problem solving of engineering challenges, proposing sustainable technological solutions. • Identify and analyse complex problems in technological processes of chemical and related industries.
2.4. Expected learning outcomes at the level of the course (3 to 10 learning outcomes)	1. Knowledge and understanding of catalyst preparation. 2. Explain and analyse wanted properties and structure of a catalyst for a given application. 3. Define and explain catalytic processes in oil refining and petrochemical industries.

	4. Define and explain catalytic processes in wastewater treatment. 5. Apply the knowledge of catalytic processes for obtaining desired products. 6. Define the demands and requisites of green chemistry.
2.5. Course content (syllabus)	**WEEK 1.** Introductory lecture, repetition of key definitions and terms: homogenous and heterogenous systems, kinetic models and reaction orders, activation energies; commercial importance of catalytic processes. **WEEK 2.** Synthesis and preparation of inorganic and polymeric catalysts; shaping of catalysts. **WEEK 3.** Surface and morphology characterization (AFM, SEM, EDX, XRD, WAXS) **WEEK 4.** Composition and electronic structure characterization (ICP-MS, EPR, XPS) **WEEK 5.** Partial exam. **WEEK 6.** Desulfurization and hydrotreating, cracking and reforming in oil refining. **WEEK 7.** Isomerization and alkylation in oil refining. **WEEK 8.** Hydrogenation and oxidation in petrochemical industry. **WEEK 9.** Preliminary exam. **WEEK 10.** Catalytic wastewater treatment at elevated temperature and pressure. **WEEK 11.** Catalytic wastewater treatment at normal temperature and pressure. **WEEK 12.** Essentials of green chemistry and the application of catalytic processes. **WEEK 13.** Partial exam. **WEEK 14.** Presentation of student independent assignments. **WEEK 15.** Presentation of student independent assignments.
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: *Field work*: industrial visit (oil refinery). *Laboratory*: preparation and application of a catalyst for wastewater treatment. *Independent assignments*: case study of selected industrial catalytic processes.
2.8. Student responsibilities	

2.9. Monitoring student work									
	Class attendance	YES		Research	YES		Oral exam		NO
	Experimental work	YES		Report	YES		(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)	Course materials prepared by the course teachers for lectures, seminars and laboratory exercise.		www.fkit.unizg.hr
	G. Rothenberg, Catalysis: Concepts and Green Applications, Wiley-VCH Verlag, Weinheim, 2008.		
	U. Hanfeld, L. Lefferts, Catalysis: An Integrated Textbook for Students, Wiley-VCH Verlag, Weinheim, 2018.	2	
	S. Parsons, Advanced Oxidation Processes for Water and Wastewater Treatment, IWA Publishing, London, 2004.	2	
	R.A. Sheldon, I. Arends, U. Hanfeld, Green Chemistry and Catalysis, Wiley-VCH Verlag, Weinheim, 2007.	1	
2.11. Optional literature	M. Absi-Halabi, J. Beshara, H. Qabazard, A. Stanislaus, Catalysts in Petroleum Refining and Petrochemical Industries 1995, Volume 100, Elsevier, 1995.		
2.12. Other (as the proposer wishes to add)			