University of Zagreb

1. GENERAL INFORMATION				
1.1 Course teacher	Prof. Zvjezdana Findrik Blažević, PhD Prof. Ana Vrsalović Presečki, PhD		1.6 Year of the study	1. year, 1. semester
1.2 Name of the course	Trends in Biotechnology		1.7 ECTS credits	5
1.3 Associate teachers	Dino Skendrović, 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	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	To introduce students to the principles and importance of biotechnology in the modern chemical industry. Students will also be introduced to the application of the methodology of chemical engineering in bioprocesses, particularly with methods of modelling and optimization of the process. Encourage students to think critically about economic and ecological aspects. Introduce students with trends in biotechnology with regard to the methods of conducting the process; integrated processes and cascade reactions.
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. • 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. • Optimise complete and sustainable technological processes using analysis and modelling aimed at waste minimization utilising the strategy of the closed cycle manufacturing. • Independently organise and plan timelines, apply a general methodology for project planning and management in a business environment.

	• Create a critical analysis, evaluation and interpretation of personal results, and compare them with existing data in scientific and expert literature. • Investigate and analyse implementation of innovative and incoming chemical technologies in multidisciplinary environment. • Demonstrate independence and reliability in independent work, as well as effectiveness, reliability and adaptability in teamwork. • Outline results of independent and teamwork in a written and oral form to non-experts and experts in a clear and coherent way. • 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)	• To collect and analyse the available literature data and critically compare the production methods of industrially significant chemicals by using chemical and biotechnological methods, and working in teams. • To create experimental plan, collect data using advanced laboratory procedures and analytical methods. • To apply numerical methods for estimating kinetic parameters. • To develop the mathematical model of the process, optimize the process and select the optimal reactor set-up for the process. • To develop self-awareness of the need for the implementation of integrated processes for economic and environmental benefit of the society.
2.5. Course content (syllabus)	**WEEK 1.** Introduction to bioprocesses. **WEEK 2.** Fermentation and industrial biotransformation; biotechnology products. **WEEK 3.** Students will be given seminars on the production of important industrial chemicals through biotechnological procedures in comparison to chemical processes. They will present their work at the end of the semester in the form of power-point presentations and written seminars (work in team). **WEEK 4.** Industrial production of enzymes. Sources of biocatalysts, methods of isolation and purification. **WEEK 5.** Integrated bioprocesses – definition, significance and application (examples). **WEEK 6.** Multi-enzyme biotransformations. Process development with examples. **WEEK 7.** Bioprocess modelling. Kinetic models. **WEEK 8.** Partial exam. **WEEK 9.** Bioprocess modelling. Bioreactors. Mass balances. **WEEK 10.** Bioprocess optimization. Methods. Goal functions and examples. 1st part. **WEEK 11.** Bioprocess optimization. Methods. Goal functions and examples. 2nd part. **WEEK 12.** Immobilization of enzymes and cells. Basics, technologies and application. 1st part. **WEEK 13.** Immobilization of enzymes and cells. Basics, technologies and application. 2nd part. **WEEK 14.** Non-convential media in biocatalysis. **WEEK 15.** Presentation of student seminars. Discussion. **WEEK 16.** Partial exam. During the laboratory exercises students will measure the kinetics of complex enzymatically catalysed biotransformations. Non-linear regression analysis of the experimental data will be done to estimate the kinetic parameters. Using the obtained data mathematical

	model in the reactor will be developed. Mathematical model will be used to optimize the process conditions and to select the appropriate reactor set-up for process implementation.

2.6. Format of instruction:			2.7. Comments:
	☒ lectures ☒ seminars and workshops ☒ exercises ☐ online in entirety ☐ partial e-learning ☐ field work	☒ independent assignments ☐ multimedia and the internet ☒ laboratory ☐ work with mentor ☐ (other)	

2.8. Student responsibilities	Students have a responsibility of attending lectures, seminars and laboratory exercises (min 75 %). Students should deliver a lab report, seminar work and give a presentation of their seminar work. Students can pass the exam by taking partial test, or regular exam.

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	

2.10. Required literature (available in the library and/or via other media)	Title	Number of copies in the library	Availability via other media
	Lecture handouts, prepared by the course teacher, available through the course website		www.fkit.unizg.hr
	Industrial biotechnology, Products and Processes, 1st ed, Christoph Wittmann and James C. Liao. Eds. 2017, Wiley-VCH Verlag GmbH & Co. KGaA	2	NO
	Biocatalysis An Industrial Perspective, Gonzalo de Gonzalo and Pablo Domínguez de María Eds., 2018, The Royal Society of Chemistry	1	NO
	Biocatalysis, Andreas Bommarius, Bettina Riebel, 2005, Wiley-VCH Verlag GmbH & Co. KGaA	1	

2.11. Optional literature	Basic Bioreactor Design, Klaas van't Riet and Johannes Tramper Eds. CRC Press Book, 1991.
	Biochemical Engineering, 2nd Edition, Douglas S. Clark, Harvey W. Blanch Eds., CRC Press, 1995

2.12. Other (as the proposer wishes to add)	