University of Zagreb

1. GENERAL INFORMATION				
1.1. Course teacher	Assist. Prof. Mario Nikola Mužek, PhD Assist. Prof. Damir Barbir, PhD		1.6. Year of the study	1st year (2nd semester)
1.2. Name of the course	Sustainable Technologies and Development		1.7. ECTS credits	5
1.3. Associate teachers			1.8. Type of instruction (number of hours L + E + S + e-learning)	Total: 60 (L: 30, E: 30, S: 0)
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	The application of preventive environmental strategies in the chemical and technological (manufacturing) processes, products and activities, according to the principle: cleaner production - sustainable development, in order to increase production efficiency and reduce risks to the environment and human health.
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. • 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.

	• Plan, document and monitor developmental activities of complex sustainable technological systems and processes. • Identify and discuss advantages, disadvantages and limitations of certain methods for preparation, synthesis, analysis and processing of samples in accordance with sustainable development and life cycle of products and processes. • Evaluate technological processes and products from the perspective of high functionality in different conditions and environmental effects. • Demonstrate independence and reliability in independent work, as well as effectiveness, reliability and adaptability in teamwork.
2.4. Expected learning outcomes at the level of the course (3 to 10 learning outcomes)	- assess contemporary environmental problems - describe the concept and principles of sustainable technology and development - apply the principle of cleaner production - sustainable development in some industrial processes - propose an energy efficient and completed technological process - organize the implementation of environmental management systems and quality assurance.
2.5. Course content (syllabus)	**1st week**: Introduction. Development and the environment. Important concepts. Contemporary issues in society. The objectives of environmental engineering strategy with the aim of sustainable development. **2nd week**: Linking industrial activity and social sciences and environmental sciences. Assessing the impact of chemical-technological processes on the environment. Origin and distribution of pollutants in air, soil and water, global warming and the greenhouse effect. Ozone holes. Acid rain. Energy efficiency of technological processes. Natural Resources (mineral raw materials, energy). Natural and anthropogenic pollutants. Carbon, sulfur and nitrogen cycles. **3rd week**: Ecologycal footprint. Carbon footprint. CO_2 vs. global warming. CO_2 discharge fee in the environment. Emissions and trade of emissions. Reduction of CO_2 emissions. Adsorption and storage of CO_2. **4th week**: The basics of sustainable development. The concept and evolution of sustainable development. Principles and models of sustainable development. Indicators of sustainable development, their management and implementation. **5th week**: Sustainable development components. Society. Economy. Environment. Ecological sustainability and industry. Linear and cyclical models of production. The concept of "At the end of the pipeline" (waste management) and waste treatment technology (physical, chemical and biological). The concept of cleaner production. **6th week**: Life Cycle Assessment (LCA). 1 Defining objectives, subjects and areas of application. 2. Life Cycle Inventory Analysis (LCI). 3. Life Cycle Impact Assessment (LCIA). Influence category. Description, categories and indicator units of impact. Standardization. Evaluation. 4. Interpretation of results. Other LCA methods. **7th week**: ”Cost-benefit” analysis in environmental engineering as an indicator of proper environmental management strategy. Viewing and control of overall mass balance in industrial processes in environmental engineering. **8th week**: Partial Exam **9th week**: Case study. **10th week**: Examples of the application of the ”cleaner” production concept on certain industrial processes. Best available technology (BAT) - principles, the implementation of sustainable and similar processes for the environment. **11th week**: The role of sustainable technologies in the development of new chemical-technological processes for the protection of heritage and ensure sustainable - sustainable, rather than survive development. Technological processes using industrial waste as raw material. Selected examples.

	12th week: Cement production - example of sustainable technology and development. Increased production efficiency and product quality. **13th week**: European Union Directives (IPPC, WID, BATNEEC, BREF) for the prevention and control of pollution in the cement industry. **14th week**: Technological processes of solidification and stabilization of industrial waste materials. Test methods for new construction products with addition of industrial waste - use value. Methods of testing new products with industrial waste-ecological acceptability - leaching tests (leaching). **15th week**: Partial Exam Exercises. Analysis and application of industrial waste as a valuable raw material for the production of new materials. Influence of waste materials on the environment (water and soil). Recovery of waste solid materials - saturated zeolite, concrete, brick and glass. Leaching tests of hazardous solid waste. Analysis of the cement kiln dust and the possibility of use. Solidification and stabilization of sludge with hazardous waste.
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 of a minimum of 80% of all lectures and a 100% of laboratory exercises

2.9. Monitoring student work									
	Class attendance	YES		Research		NO	Oral exam	YES	
	Experimental work	YES		Report	YES		(other)		
	Essay		NO	Seminar paper		NO	(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**
	R. Vos, Technology and Innovation for Sustainable Development, Bloomsbury Publishing, 2015.	2	
	N.A. Ashford, R.P. Hall, Technology, Globalization and Sustainable Development: Transforming the Industrial State, First ed., Routledge, 2018.	1	
	T.E. Graedel, B.R.Allenby, Industrial ecology, Second ed., Pearson education Inc. Upper saddle River, 2003.	2	

2.11. Optional literature	M.L. Davis, D.A. Cornwell, Introduction to Environmental Engineering, McGraw Hill, New York, 1998.		
	K.Y. Show, X. Guo, Industrial Waste, InTech, Rijeka, 2012.		
	L.K. Wang, Y.T. Hung, H.H. Lo, C. Yapijakis, Handbook of Industrial and Hazardous Wastes Treatment, Marcel Dekker Inc., New York, 2004.		
	R.D. Spence, C. Shi, Stabilization and Solidification of Hazardous, Radioactive, and Mixed Wastes, CRC Press, Boca Raton, 2005.		
2.12. Other (as the proposer wishes to add)			