University of Zagreb

1. GENERAL INFORMATION				
1.1 Course teacher	Prof. Stanislav Kurajica, PhD		1.6 Year of the study	1st (1st semester)
1.2 Name of the course	Nanotechnology		1.7. ECTS credits	5
1.3 Associate teachers	Prof. Sanja Lučić Blagojević, PhD Filip Brleković, 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	Accepting of the basic terms of nanotechnology. Acquiring knowledge on properties of nanomaterials. Getting acquinted with methods of preparation and characterization of nanomaterials. Acquaint with the most important kinds of nanomaterials and nanotechnologies and its applications.
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. • 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. • 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. • 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)	1. Explain certain material properties and reasons for changing of materials properties occurring on a nano-scale 2. Describe ideas, concepts and techniques in the area of nanotechnology and being able to judge them critically 3. Differentiation of nanomaterials manufacturing methods, understanding of those methods and the ability of perceiving their advantages and disadvantages. 4. The ability to analyze the role and apply the science and engineering of materials in nanotechnologies

	5. Explaining connection between structure and properties of nanoobjects and integrated nanosystems 6. Describing various methods of nano-scale characterization and knowing of principles of these methods, their advantages and disadvantages 7. To perceive of current limitations in the development of nanomaterials end ethical scruples appearing in the field of nanotechnology 8. Demonstration of communication skills, the ability of critical thinking and understanding the need for further education
2.5. Course content (syllabus)	**WEEK 1.** Concepts of nanoscience and nanotechnology, molecular nanotechnology. History of nanotechnology, Gordon E, Moore, Richard P. Feynman, Eric K. Drexler, R. Kurzweil. Phenomena on nano-level: quantum effects, surface to volume ratio, the dominance of electromagnetic forces. **WEEK 2.** Properties of nanomaterials: physical, mechanical, chemical, optical, electrical. **WEEK 3.** Tunnelling effect, quantum confinement, quantum dots, nanostructure, magical numbers. Hall-Petch effect, lotus effect. **WEEK 4.** Characterization of nanomaterials. Scanning electron microscope, transmission electron microscope, scanning tunnelling microscope, atomic force microscope. **WEEK 5.** Nano-manufacturing: top-down approach: photolitography, soft litography, micro contact printing, dip-pen nanolithography, high-energy milling, PVD, CVD. **WEEK 6.** Nano-manufacturing: bottom-up approach: precipitation, crystallization, colloids, colloid stabilization, self-assembly, micelles, thin films, self-assembled monolayers, dendrimers, sol-gel method. Nanomanipulation. **WEEK 7.** Trends in nanotechnology: Nanomaterials (nano-structured materials, smart materials, ageless materials), nanoproducts (electronics, medicine, environment, industrial technology). Nanorobots. The applicative potential of nanomaterials. Sociological acceptance of nanomaterials. Risks of nanotechnology. Future of nanotechnology. **WEEK 8.** Partial exam **WEEK 9.** Carbon nanostructures; Fullerene – synthesis, properties, reactivity, potential application; Carbon nanotubes – molecular and supramolecular structure, intrinsic properties, synthesis, purification, modification, application. **WEEK 10.** Nanoscale electronic, Development of microelectronic devices and technology, Structure and operation of MOF transistor; Transistor scaling, Nanoscaled MOFSET transistors;. **WEEK 11.** Molecular electronic – possibilities, preparation and investigation of molecular devices; Molecular switches, transistors and similar devices; Single electron electronic devices. **WEEK 12.** Polymer nanocomposites – preparation, structure and advanced multifunctional properties **WEEK 13.** Nanobiotechnology – modification of nanoobjecsts for application in nanobiotechnology; **WEEK 14.** Biosensors; Targeted drug delivery using nanoobjects; Optical imaging using nanoobjects; **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									
2.9. Monitoring student work	Class attendance	YES		Research		NO	Oral exam		NO
	Experimental work	YES		Report		NO	(other)		NO
	Essay		NO	Seminar paper	YES		(other)		NO
	Preliminary exam	YES		Practical work		NO	(other)		NO
	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**
	Di Ventra M., Evoy S., Heflin R.J., Introduction to Nanoscale Science and Technology, Springer, 2004.	1	
	Owens P., Introduction to Nanotechnology, John Wiley & Sons, 2003.	2	
	J. Ramsden, Nanotechnology, Ventus Publishing ApS, 2011.	2	
2.11. Optional literature			
2.12. Other (as the proposer wishes to add)			