

FACULTY OF CHEMISTRY

**SUBJECT CARD****Name of subject in Polish** Inżynieria nanomaszyn**Name of subject in English** Engineering of Nanomachines**Main field of study (if applicable):** Chemical Nano-Engineering**Specialization (if applicable):** .....**Profile:** academic**Level and form of studies:** 2nd level, , full-time**Kind of subject:** obligatory**Subject code** .....**Group of courses** NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				15
Number of hours of total student workload (CNPS)	30				30
Form of crediting	crediting with grade*				crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points	1				1
including number of ECTS points for practical classes (P)					1
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.7				0.7

\*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. *Elemental mathematics: Analysis I and II, algebra*
2. *Elemental physics: Physics I and II*
3. *Elemental chemistry: General chemistry, organic chemistry*

**SUBJECT OBJECTIVES**

- C1 Application of thermodynamics and organic chemistry to nanoengineering.  
 C2 Understanding structure and dynamics of molecules elements of molecular motors.  
 C3 Gives ability to select Artificial Molecular Machines for particular application.

**SUBJECT EDUCATIONAL EFFECTS****Relating to knowledge:***A person who passed the subject**PEU\_W01 – knows fundamentals of structure and thermodynamics of molecules**PEU\_W02 – knows fundamentals of the description of artificial molecular machines**PEU\_W03– knows fundamentals of the functioning molecular machines*

**Relating to skills:***A person who passed the subject**PEU\_U01 – can solve elementary structural and thermodynamics problems related to Artificial Molecular Machines**PEU\_U02– can select MM according to the required application.**PEU\_U03– can find a design for particular molecular level job***Relating to social competences:***A person who passed the subject**PEU\_K01 – possesses ability of combining information from disparate fields of science (mathematics, physics, chemistry, mechanics) to arrive at coherent conclusions***PROGRAMME CONTENT**

<b>Lecture</b>		<b>Number of hours</b>
Lec 1	Elements of molecular structures related to Molecular Machines (MM) Laws of thermodynamics. Entropy, free energy and free enthalpy. Potential energy surfaces, External potential and MM interactions Thermal fluctuations. Ratchet and Brownian machines. Rotaxanes. Molecular shuttles. Molecular switches. The power sources for artificial molecular-level machines. Applications of MM	15
	Total hours	15

<b>Seminar</b>		<b>Number of hours</b>
Sem1	Mechanically interlocked molecules. Mechanical bonds versus covalent bond Molecular pump From molecular shuttle to switches Unidirectional transport Motors and car race Nano-molecular machines powered by light Nano-molecular machines powered by chemistry Surface nanomachines	30
	Total hours	30

**TEACHING TOOLS USED***N1. Lecture: multimedia presentation**N2. Seminar: a set of problems, presented to the students for individual elaboration and discussed during the seminar***EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

<b>Evaluation (F – forming during</b>	<b>Learning outcomes code</b>	<b>Way of evaluating learning outcomes achievement</b>
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semester), P – concluding (at semester end)		
F1	<i>PEU_U01, PEU_U02, PEU_U03</i>	Presentation
F2	<i>PEU_W01, PEU_W02, PEU_W03</i>	Exam
P	<b>P= 0.5(F1+F2)</b> Condition of passing: P=50% or more	

<b>PRIMARY AND SECONDARY LITERATURE</b>
<b><u>PRIMARY LITERATURE:</u></b>
1. Peter Atkins, Julio De Paula, "Atkins' Physical Chemistry", Eighth edition, Oxford University Press, Oxford 2006
2. Collection of scientific journal papers
<b><u>SECONDARY LITERATURE:</u></b>
1. NIST WebBook - Chemistry
<b>SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)</b>
<b>Prof. Szczepan Roszak, Szczepan.roszak@pwr.edu.pl</b>