UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Trajnostni vidiki v procesni tehniki
Course title:	Sustainable Process Engineering

Študijski program in stopnja **Study programme and level**	**Študijska smer** **Study field**	**Letnik** **Academic year**	**Semester** **Semester**
Sonaravne tehnologije in sistemi v strojništvu - 3. stopnja	/	1./2.	zimski/letni
Sustainable technologies and systems in mechanical engineering - 3rd cycle	/	first/second	winter/summer

Vrsta predmeta / Course type izbirni/elective

Univerzitetna koda predmeta / University course code:

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**	**Laboratorijske vaje** **work**	**Druge oblike študija**	**Samost. delo** **Individ. work**	**ECTS**
10		30	10	/	250	10

Nosilec predmeta / Lecturer: izr. prof. dr. Viktor Grilc

Jeziki / Languages:	**Predavanja / Lectures:**	slovenski/Slovenian
	Vaje / Tutorial:	slovenski/Slovenian

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
• Izpolnjeni splošni pogoji za vpis na ta nivo študija.	Fulfilled general entrance qualifications for this level of studies

Vsebina:	**Content (Syllabus outline):**
• Osnovni pojmi in definicije procesne tehnike. • Prenos toplote. Mehanizmi prenosa toplote. Stacionarno prevajanje. Nestacionarno prevajanje. Konvektivni prenos toplote. Koeficienti toplotnega prestopa. Korelacije. • Prenos snovi. Mehanizmi snovnega prenosa. Stacionarna difuzija. Konvektivni snovni prenos. Koeficienti snovnega	• Basic definitions and concepts of process engineering. • Heat Transfer. Mechanisms of heat transfer. Steady and unsteady heat transfer. Conductive, convective and radiation heat transfer. The coefficients of heat exchange. Correlations. • Mass transfer. Mechanisms of mass transfer. Stationary diffusion. Convective mass transfer. The coefficients of mass

prenosa. Korelacije za izračun koeficientov prestopa. • Separacijski procesi. Fazno ravnotežje. Kontinuirni in stopenjski kontakt v napravah. Načrtovanje in analiza separacijskih procesov. Sedimentacija. Filtracija. Centrifugiranje. Uparjanje. Kristalizacija. Destilacija. Ekstrakcija. Kromatografija. Dializa. Membranski procesi. Aplikacije v kemijski in farmacevtski industriji. • Kemijska reakcija. Kinetični in termodinamski podatki. Kemijski reaktor. Hitrostna enačba. Enostavne in kompleksne reakcije. Kinetična analiza podatkov. • Reaktorji za homogene reakcije. Šaržni reaktor. Mešalni reaktor. Cevni reaktor. • Heterogene katalizirane reakcije. Mehanizem in hitrostna enačba katalitske reakcije. Transport snovi in toplote preko površine katalizatorja in znotraj katalitskega zrna. Globalna hitrost reakcije. • Reaktorji za heterogeno katalizirane reakcije. Reaktor s strnjenim slojem. Reaktor s fluidiziranim slojem. Reaktor z goščo. Kapalni reaktor. Membranski reaktor. • Osnove dimenzioniranja reaktorjev. Snovna in toplotna bilanca. Tok tekočin v mešalnikih in reaktorjih. Avtomatska regulacija kemijskih reaktorjev. • Okoljevarstveni vidiki procesnih industrij, preprečevanje onesnaževanja na izvoru in obdelava neogibnih emisij.	transfer. The correlation coefficients for calculating the mass transfer fluxes. • Separation processes. The phase balance. Continuous and speed contact devices. Design and analysis of separation processes. Sedimentation. Filtration. Centrifugation. Evaporation. Crystallization. Distillation. Extraction. Chromatography. Dialysis. Membrane processes. Applications in the chemical and pharmaceutical industries. • Chemical reaction. Kinetic and thermodynamic data. Chemical reactor. Rate equation. Simple and complex reactions. Kinetic analysis of the reaction data. • Reactors for homogeneous reactions. Batch reactor. Mixing reactor. Tubular reactor. • Heterogeneous catalyzed reactions. The mechanism and rate equation of catalytic reactions. Transport of mass and heat to the surface of the catalyst and within the catalyst grains. The global reaction rate. • Reactors for heterogeneously catalyzed reactions. The reactor with a packed bed. The reactor is a fluidized bed. The reactor with the slurry. Dropping the reactor. Membrane reactor. Biochemical reactions and reactors. • Basics of reactors design. Material and thermal balances. Fluid flow in the mixers and reactors. Automatic control of chemical reactors. • Principles of sustainable production. Resource conservation. Environmental aspects of process industries. Pollution prevention and emission treatment.

Temeljni literatura in viri / Readings:

1. Hriberšek, M. (2005) *Procesna tehnika,* 1.del. Maribor: Univerza v Mariboru, Fakulteta za strojništvo.
2. Holloway, M.D. et al. (2012) *Process Plant Equipment*. New York: John Wiley and Sons.
3. Seader, J.D., Henley, E.J., Roper, D.K. (2011) *Separation Process principles*. 3rd edition, New York: John Wiley and Sons.
4. Vogel, G. H. (2005). *Process Development*. Weinheim: Wiley-VCH Verlag.

5. Levenspiel, O. (2003). *Chemical Reaction Engineering*. 3rd edn., New York: John Wiley and Sons.
6. Perry, H. R., Green, D. (2008). *Chemical Engineer's Handbook*. 8. edn., New York: McGraw-Hill.
7. Schwister, K. (2000).*Taschenbuch der Verfahrenstechnik*. Leipzig: Carl Hanser Verlag.
8. Katoh, S., Yoshida, F. (2009). *Biochemical Engineering*. Weinheim: Wiley-VCH.
9. Fränzle, S., Markert, B., Wüschmann, S. (2012). *Introduction to Environmental Engineering*. Weinheim: Wiley-VCH.

Cilji in kompetence:

- Učna enota prispeva k razvoju naslednjih splošnih in predmetno-specifičnih kompetenc:
- Osnovni namen predmeta je študente seznaniti z osnovami toplotnega in snovnega transporta, ki se odvijata med potekom kemijske ali biokemijske reakcije, z osnovami dimenzioniranja kemijskih in biokemijskih reaktorjev ter z najvažnejšimi separacijskimi procesi, uporabljanih v kemijskih in procesnih industrijah. Ta znanja so potrebna pri skupnem delu s strokovnjaki drugih profilov (strojniških, elektrotehniških, računalniških...) pri razvoju novih produktov in tehnologij.

Objectives and competences:

- Learning Unit contributes to the development of generic and subject-specific competences:
- The main purpose of the course is to acquaint students with the fundamentals of heat and mass transfer, which take place in chemical or bio-chemical reactions, the basics of design and sizing of chemical and biochemical reactors and the most important separation processes used in chemical and process industries . This knowledge is needed to work together with experts from other profiles (mechanical, electrical, civil and computer engineering) in the development of new products and technologies.

Predvideni študijski rezultati:

- Znanje in razumevanje: Pridobiti sposobnost in osnovna znanja, ki jih potrebujejo pri načrtovanju procesov s snovno pretvorbo in separacijskih procesov.
- *Uporaba:* Osvojiti metodološke prijeme/orodja za analizo in sintezo kompleksnih kemijsko-tehnoloških sistemov. Reflektirati vsebine z drugih strokovnih disciplin in jih povezati s pridobljenim znanjem. Spretnosti uporabe domače in tuje literature ter drugih virov, zbiranje in interpretiranje podatkov, sposobnost kritične strokovne analize, branje in izdelav tehnoloških načrtov ter ustnega in pisnega (vključno elektronskega) poročanja.

Intended learning outcomes:

- Knowledge and understanding: The ability to obtain and basic skills that students will need in process design with material conversion and separation processes.
- Application: Acquire the methodological techniques / tools for the analysis and synthesis of complex chemical- technological systems. To reflect the content of other professional disciplines and connect them with knowledge. Skills of using of domestic and foreign literature and other sources, acquisition and interpretation of data, critical analysis, reading and elaboration of technological plans, and oral and written (including electronic) reporting.

Metode poučevanja in učenja:	Learning and teaching methods:
• *predavanja z aktivno udeležbo študentov* (razlaga, diskusija, vprašanja in odgovori, teoretični in računski primeri, reševanje tipskih problemov – problemski pristop); • *vaje in laboratorijske vaje* (načrtovanje in izvajanje poskusov, analiza eksperimentalnih podatkov, reševanje strokovnih problemov, projektno delo, dokumentiranje); • *samostojno delo študentov* (individualni študij, priprava, predstavitev in zagovor projektne ali raziskovalne naloge).	• lectures with active participation of students (explanation, questions and answers, discussion, theoretical and computational examples, solving of model problems - problem approach); • exercises and laboratory work (design and conduct experiments , analyze experimental data, solving technical problems, project work , documentation); • individual work of students (individual study, preparation, presentation and defense of project or research paper).

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
seminarska naloga	33 %	coursework
pisni izpit	33 %	written exam
ustno izpraševanje	34 %	oral exam

Reference nosilca / Lecturer's references:

Gl. COBISS, Viktor Grilc, 3072

1. Bezjak, R., Grilc, V. (2011) Thermal recycling of waste glass wool insulation materials. V: 13th International Waste Management and Landfill Symposium, 3-7 October 2011, S. Margherita di Pula (Cagliari), Sardinia, Italy. *Proceedings : Sardinia 2011*. str. [1-7].
2. Sežun, M., Grilc V., Zupančič, G.D., Marinšek-Logar, R. (2011) Anaerobic digestion of brewery spent grain in a semi-continuous bioreactor : inhibition by phenolic degradation products. *Acta chimica slovenica*, 2011, vol. 58, no. 1, str. 158-166.
3. Zupančič, G.D., Grilc, V. (2011) Potencial, ki še zdaleč ni izkoriščen. *Embalaža, okolje, logistika*, ISSN 1855-4849, april 2011, št. 58, str. 33-35.
4. Schoeffer, Ž., Grilc, V. (2011) Regeneracija goriva iz usedlin gorivnih rezervoarjev petro-trgovske verige. *Gospodarjenje z okoljem*, maj 2011, letn. 20, št. 78, str. 7-11.
5. Zupančič, G.D., Grilc, V. (2012) Anaerobic treatment and biogas production from organic waste. V: KUMAR, Sunil (ur.). *Management of organic waste*. Rijeka: InTech, 2012, str. 3-28. http://www.intechopen.com/articles/show/title/anaerobic-treatment-and-biogas-production-from-organic-wastes.
6. Cukjati, N., Zupančič, G.D., Roš, M., Grilc, V. (2012) Composting of anaerobic sludge : an economically feasible element of a sustainable sewage sludge management. *Journal of environmental management*, ISSN 0301-4797, 2012, vol. 106, str. 48-55.
7. Ninčevič, A., Grilc, V. (2012) Problematika ravnanja z nevarnimi odpadki v veliki zdravstveni ustanovi. *Gospodarjenje z okoljem*, 2012, let. 21, št. 83, str. 2-10.