UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Procesni sistemi
Course title:	PROCESS SYSTEMS
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Procesno strojništvo (smer)	2. letnik	2. semester

Univerzitetna koda predmeta/University course code:	0563382
Koda učne enote na članici/UL Member course code:	3035-V

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
30		30			40	4

Nosilec predmeta/Lecturer:	Iztok Golobič
Vrsta predmeta/Course type:	Izbirni strokovni predmet /Elective specialised course

Jeziki/Languages:	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites:
Izpolnjevanje pogojev za vpis v Visokošolski strokovni študijski program I. stopnje Strojništvo - Projektno aplikativni program.	Meeting the enrollment conditions for the MECHANICAL ENGINEERING - Project Oriented Applied Programme.

Vsebina:	Content (Syllabus outline):
1. Uvod v procesne sisteme: - Kronološki pregled, procesni sistemi in trajnostni razvoj; - Uporaba procesnih tehnologij na področju zdravja, prehrane in zmanjšanja okoljskega onesnaževanja.	1. Introduction to process systems: - Chronological overview, the role process systems in sustainable development; - Use of process technologies in the fields of health, food and environmental pollution control.
2. Termodinamične osnove ločevalnih procesov: - Zmesi, raztopine; - Binarni sistemi, parno kapljevito ravnotežje, azeotropne zmesi.	2. Thermodynamics of separation processes: - Mixtures, solutions; - Binary systems, vapor-liquid equilibrium, azeotropic mixtures.
3. Termični procesni sistemi:	3. Thermal process systems:

 Termični procesni sistemi brez in s kemijsko reakcijo;
 Učinkovitost termičnih procesnih sistemov, krožno gospodarstvo in trajnostni razvoj.

4. Termični separacijski sistemi:
 Osnovni termični separacijski sistemi;
 Kontinuirani in nekontinuirani termični separacijski sistemi.

5. Uparjalniki:
 Vrenje in vrelna krivulja, saržni in kontinuirni uparjalniki;
 Tankoplastni uparjalnik.

6. Destilacijske in rektifikacijske naprave:
 Saržna in kontinuirna destilacija, vračilni tok, odgonska in pojačevalna kolona;
 Rektifikacijska naprava, McCabe - Thielov diagram.

7. Sušilniki:
 Vlažen zrak, Mollierov h-x diagram, eksergijski diagram vlažnega zraka;
 Enostopenjsko in večstopenjsko sušenje, kinetika sušenja in sušilniki.

8. Izbira sušilnega procesa:
 Izbira sušilnega procesa v odvisnosti od vrste vlažnega blaga v farmacevtski, prehrambeni in procesni industriji;
 Sušilnik s fluidiziranim slojem.

9. Energijska in eksergijska analiza sušilnega procesa:
 Energijska analiza psihrometričnega procesa sušenja;
 Eksergijska analiza psihrometričnega procesa sušenja.

10. Liofilizacija:
 Proces liofilizacije. Prenos toplote in snovi pri liofilizaciji;
 Liofilizatorji v prehrambeni in farmacevtski industriji.

11. Flimsko oblaganje tablet:
 Sistemi za filmsko oblagaje tablet;
 Razpršilne šobe in parametri razprševanja.

12. Bioreaktor:
 Bioreaktor;
 Modeliranje nestacionarnega prenosa toplote pri gretju in hlajenju bioreaktorja z grelnim plaščem in s cevno kačo v bioreaktorju.

13. Bioreaktor z membranskimi sistemi:
 Membrane, membranski procesi;
 Uporaba membranskih procesov za čiščenje bioreaktorskega produkta.

14. Bioseparacijski sistemi:
 Bioseparacijski procesi, kromatografija;
 Fluorescenčno preučevanje procesov.

15. Študentska predstavitev seminarskega dela iz procesnih sistemov:
 Timsko projektno teoretično in eksperimentalno delo;

 Thermal process systems with and without chemical reactions;
 Efficiency of thermal process systems, circular economy and sustainable development.

4. Thermal separation systems:
 Basic thermal separation systems;
 Continuous and batch thermal separation systems.

5. Evaporators:
 Boiling and the boiling curve, batch and continuous evaporators;
 Thin film evaporator.

6. Distillation and rectification devices:
 Batch and continuous distillation, reflux, rectifying section, stripping section;
 Rectification device, McCabe-Thiele diagram.

7. Dryers:
 Humid air, Mollier h-x diagram, exergy diagram for humid air;
 Single- and multistage drying, drying kinetics and dryers.

8. Choosing a drying process:
 Choosing a drying process based on the type of goods to be dried in pharmaceutical, food and process industry;
 Fluidized bed dryer.

9. Energy and exergy analysis of the drying process:
 Energy analysis of the psychrometric drying process;
 Exergy analysis of the psychrometric drying process.

10. Lyophilization:
 Lyophilization process, heat and mass transfer in lyophilization;
 Lyophilizators in food and pharmaceutical industry.

11. Film coating of tablets:
 Systems for film coating of tablets;
 Spray nozzles and coating parameters.

12. Bioreactor:
 Bioreactor;
 Modelling the transient heat transfer in heating and cooling of a bioreactor with a heating jacket and an internal helical coil.

13. Bioreactor with membrane systems:
 Membranes, membrane processes;
 Using membrane processes in cleaning of bioreactor products.

14. Bioseparation systems:
 Bioseparation processes, chromatography;
 Study of processes using fluorescence.

15. Student presentation of process systems seminar work:

3 minutna predstavitev in diskusija.	Team projects, theoretical and experimental work; 3-minute presentation and discussion.

Temeljna literatura in viri/Readings:

1. Seader, J.D, Henley, E.J., Roper, D.K., Separation Process Principles with Applications Using Process Simulators, 4th Edition, Wiley, 2015.
2. Green D.W., Southard, M. Z., Perry's Chemical Engineers' Handbook, 9th Edition, McGraw-Hill Education; 2018.
3. Basile, A., Comite, A., Current Trends and Future Developments on (Bio-) Membranes: Membrane Technology for Water and Wastewater Treatment - Advances and Emerging Processes. Elsevier, 2020.
4. Basmadjian D., MassTransfer and Separation Processes, 2nd Edition, CRC Press, 2007.
5. Lieberman, N., Understanding Process Equipment for Operators and Engineers. Elsevier; 2019.
6. Mersmann, A., Kind, M., Stichlmair, J., Thermal Separation Technology: Principles, Methods, Process Design (VDI-Buch), Springer; 2011.
7. Ignatowitz, E., Kemijska tehnika, Jutro, Ljubljana, 1996.

Cilji in kompetence:	**Objectives and competences:**
Cilji: 1. Spoznati osnove procesne tehnike in spoznati osnove delovanja procesnih sistemov. 2. Razumevanje osnovnih snovnih operacij, ki temeljijo na snovnih in energijskih tokovih ter fazno ravnotežnih fenomenih. 3. Usposobiti za uporabo inženirskih orodij ob hkratnem utrjevanju inženirskega pristopa k reševanju problemov procesne tehnike Kompetence: 1. Sposobnost samostojnega dela v okviru znanja o procesnih sistemih. Razume fizikalne zakone in pojave, na katerih temeljijo procesni sistemi (S2-PAP, P1-PAP). 2. Sposobnost predstavitve strokovnih problemov na področju procesnih sistemov in njihovih rešitev v svojem okolju in širše. Obvlada temeljna strokovna znanja s področja procesnih sistemov in bistvenih komplementarnih ved (S11-PAP, P3-PAP). 3. Usposobljenost za delo v skupini in interdisciplinarno povezovanje s strokovnjaki drugih strok izven procesnih sistemov. Obvlada osnovna in potrebna specifična znanja na področju procesnih sistemov (S6-PAP, P8-PAP). 4. Upoštevanje varnostnih, funkcionalnih, gospodarskih in okoljevarstvenih načel pri svojem delu s procesnimi sistemi. Pozna glavne okoljske omejitve in probleme procesnih sistemov (S9-PAP, P5-PAP).	Objectives: 1. Educate the student on the basics of process systems and their operation. 2. Develop understanding of basic process operations based on mass and energy flows and phase equilibrium phenomena. 3. Educate the student on the use of engineering tools with simultaneous consolidation of an engineering approach to problem solving in process engineering. Competences: 1. The ability to work autonomously in the framework of knowledge about process systems provided by this study module. Understanding the laws of physics and the phenomena behind the operating principles of process systems (S2-PAP, P1-PAP). 2. The ability to present professional problems related to process systems and the solutions thereof in own environment and wider. Mastering the fundamental specialised knowledge in the field of process systems and the fundamental complementary sciences. (S11-PAP, P3-PAP). 3. Qualification for teamwork and establishing interdisciplinary relations with the professionals from other disciplines outside of process systems. Mastering the basic and required specific knowledge about process systems (S6-PAP, P8-PAP). 4. Considering the safety, functional, economic and environmental principles in their work with process systems. Knowing the main environmental restrictions and problems of process systems (S9-PAP, P5-PAP).

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanja: Poglobljeno aplikativno inženirsko znanje na področju procesnega in okoljskega inženirstva (Z1). Spretnosti: 1. Izvajanje kompleksnih operativno-strokovnih opravil na področju procesnih sistemov, ki vključujejo tudi uporabo metodoloških orodij (S1). 2. Obvladovanje zahtevnih, kompleksnih delovnih procesov na področju procesnih sistemov ob samostojni uporabi znanja v novih delovnih situacijah (1.2). 3. Diagnosticiranje in reševanje problemov v različnih specifičnih delovnih okoljih, povezanih s procesnimi sistemi (S1.3). 4. Osnova za izvirna dognanja/ stvaritve in kritično refleksijo pri reševanju problemov na področju procesnih sistemov (S1.4).	Knowledge: Thorough applicative engineering knowledge in the field of process and environmental engineering (Z1). Skills: 1. Executing complex operational-professional tasks related to process systems that incorporate usage of methodological tools (S1). 2. Mastering demanding and complex work processes in the field of process engineering by independent usage of knowledge in new working situations (1.2). 3. Problem diagnostics and solving in different and specific working environments related to process systems (S1.3). 4. Basis for unique innovations and critical reflections in solving problems in the field of process systems (S1.4).

Metode poučevanja in učenja:	**Learning and teaching methods:**
P1 Avditorna predavanja podprta s interaktivnim prikazom praktičnih primerov. P3 Avditorne vaje, kjer se teoretično znanje iz predavanj podkrepi z računskimi primeri obravnavanih področij procesnih sistemov. P4 Laboratorijske vaje z namenskimi eksperimentalnimi progami in didaktičnimi pripomočki za prikaz določanja kvalitete vode, ionske izmenjave, membranskih postopkov čiščenja vode, termičnega ločevanja alkoholih zmesi, večstopenjskega termičnega ločevanja zmesi, vakuumskega sušenja in pršilnega oblaganja tablet. P8 Izdelava in predstavitev aplikativnih seminarskih nalog iz področja procesnih sistemov. P9 Timsko razvojno raziskovalno projektno delo s predstavitvijo in razpravo. P12 Individualizirane domače naloge v spletni učilnici. P14 Virtualni eksperimenti iz področja procesnih sistemov.	P1 Lectures supported by interactive presentation of practical examples. P3 Auditorial exercises, in which theoretical content from the lectures is supplemented with practical examples of process systems problems. P4 Laboratory exercises with special-purpose didactic devices to showcase water quality testing, ion exchange, membrane water treatment, thermal separation of dilute alcohols, multistage thermal separation of mixtures, vacuum drying and spray coating of tablets. P8 Making and presenting applied seminar exercises in the field of process systems. P9 Team work (discussion pro and contra, discussion of the studied content, snow ball, structured discussion, brainstorming, project work, etc.). P12 Individualised homework in a web classroom. P14 Virtual experiments in the field of process systems.

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
Teoretična vsebine (predavanja, računske naloge)	60,00 %	Theoretical content (lectures, calculation problems)
Samostojno/skupinsko delo na vajah	20,00 %	Individual/group work during auditorial

		exercises
Seminar	20,00 %	Seminar

Reference nosilca/Lecturer's references:

Iztok Golobič:

1. **GOLOBIČ, Iztok**, ZUPANČIČ, Matevž. Wall-temperature distributions of nucleate pool boiling surfaces vs. boiling curves: a new approach. *International journal of heat and mass transfer*. 2016, vol. 99, str. 541-547, [COBISS.SI-ID 14605595].
2. SITAR, Anže, MOŽE, Matic, CRIVELLARI, Michele, SCHILLE, Jörg, **GOLOBIČ, Iztok**. Nucleate pool boiling heat transfer on etched and laser structured silicon surfaces. *International journal of heat and mass transfer*. 2020, vol. 147, str. 1-12, [COBISS.SI-ID 16885531].
3. ZUPANČIČ, Matevž, STEINBÜCHER, Miha, GREGORČIČ, Peter, **GOLOBIČ, Iztok**. Enhanced pool-boiling heat transfer on laser-made hydrophobic/superhydrophilic polydimethylsiloxane-silica patterned surfaces. *Applied thermal engineering*. 2015, vol. 91, str. 288-297, [COBISS.SI-ID 14131227].
4. MELE, Jernej, **GOLOBIČ, Iztok**, SENEGAČNIK, Andrej. A method to detect and control fully fluidized conical beds with a wide size distribution of particles in the vicinity of the minimum fluidization velocity. *Thermal science*. 2015, vol. 19, iss. 1, str. 267-276, [COBISS.SI-ID 13298459
5. GJERKEŠ, Henrik, MALENŠEK, Jože, SITAR, Anže, **GOLOBIČ, Iztok**. Product identification in industrial batch fermentation using a variable forgetting factor. *Control engineering practice*. 2011, vol. 19, iss. 10, str. 1208-1215. [COBISS.SI-ID 11995931].