PRENOS TOPLOTE IN SNOVI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	PRENOS TOPLOTE IN SNOVI
Course title:	HEAT AND MASS TRANSFER
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo, tretja stopnja, doktorski (od študijskega leta 2022/2023 dalje)	Energetske, procesne in okoljske inženirske znanosti (smer)		Celoletni	izbirni

Univerzitetna koda predmeta/University course code:	0033451
Koda učne enote na članici/UL Member course code:	7206

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
90					160	10

Nosilec predmeta/Lecturer:	Andrej Kitanovski

Izvajalci predavanj:	Iztok Golobič, Andrej Kitanovski, Matevž Zupančič
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	Izbirni predmet /Elective course

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Veljajo splošni pogoji za doktorski študij.	General prerequisites for the third level studies.

Vsebina:	**Content (Syllabus outline):**
Nadgradnja znanja o stacionarnem prevodu toplote v eno in večrazsežnem prostoru z in brez izvora toplote. Izboljšane površine za povečanja intenzivnosti prenosa toplote. Razširjene površine. Nestacionarni prevod toplote, Prevod toplote z uporabo Greenovih funkcij. Konvektivni prenos toplote (analitični in empirični pristop) brez fazne spremembe in s fazno spremembo. Stefanov problem. Prenos toplote s sevanjem. Prenos toplote na mikro in nanoskali. Analogija med prenosom impulza energije in snovi. Fickova ekvimolarna in neekvimolarna difuzija v večrazsežnem prostoru v binarnih in v večkomponentnih zmeseh. Difuzija snovi s homogeno kemijsko reakcijo. Konvektivni prenos snovi. Prenos snovi v poroznih strukturah. Prenos snovi skozi mejno površino kapljic in mehurčkov. Nestacionarni prenos snovi. Sočasni prenos toplote in snovi.	Upgrading knowledge of steady-state heat conduction in one and multi-dimensional systems with and without a heat source. Enhanced surfaces to augmentation of heat transfer. Extended surfaces. Transient heat conduction. Heat conduction by using Green's functions. Convective heat transfer (analytical and empirical approach) with and without a phase change. Stefan's problem. The radiation heat transfer. Micro and nano heat transfer. Analogy between the heat and mass transfer. Fick's equimolar and non-equimolar diffusion in binary and multicomponent mixture in one- and multi-dimensional sistem. Mass diffusion with homogeneous chemical reactions. Convective mass transfer. Mass transfer in porous media. Mass transfer through the boundary layer of drops and bubbles. Transient mass transfer. Simultaneous heat and mass transfer.

Temeljna literatura in viri/Readings:

[1] Incropera F.P., DeWitt P.D., Bergman, T.L, Lavine, A.S.: Fundamentals of Heat and Mass Transfer, Sixth Edition, John Wiley and Sons, New York, 2007.

[2] Baehr H.D., Stephan K.: Heat and Mass Transfer, Springer Verlag, Berlin, 1998.

[3] Lienhard IV J.H., Lienhard V J.H.: A Heat Transfer Textbook, Third Edition, Phlogison Press, Cambridge, Massachusetts, 2003.

[4] Gašperšič B.: Prenos toplote, Univerza v Ljubljani, Fakulteta za strojništvo,

Ljubljana, 2001.

[5] Basmadjian D.: Mass Transfer and Separation Processes, CRC Press, Boca Raton, 2007.

[6] Greene G., Cho Y., Hartnett J., Bar-Cohen A.: Advances in Heat Transfer, 39 / serial publications, Elsevier, Oxford, 2006.

Cilji in kompetence:	**Objectives and competences:**
Cilji: Glavni cilj predmeta je nadgradnja temeljnih znanj študentov za obvladovanje kompleksnih problemov povezanih s prenosom toplote in snovi v toplotni in procesni tehniki. Predmet razvija sposobnost samostojnega učenja, osebne in profesionalne rasti ter daje osnovo za razumevanje transportnih pojavov, ki so predpogoj za popis mehanizmov prenosa toplote in snovi. Vsebina in način izvedbe predmeta omogoča avtonomno učenje in utrjevanje samostojnega razmišljanja ter daje podlago za samostojno raziskovalno delo. **Kompetence:** Študent osvoji nova znanja in nadgradi že pridobljena znanja za modeliranje transportnih pojavov. Nadalje študent na konkretnih primerih pridobi znanje in praktične izkušnje za obvladovanje računalniških orodij za simulacijo tokovnih in temperaturnih razmer ter polja koncentracij pri prenosu toplote in snovi v elementih toplotne in procesne tehnike. Študent si z eksperimentalnim laboratorijskim delom na pilotnih napravah pridobi praktične izkušnje in rezultate za preverjanje rezultatov simulacij.	**Goals:** The main objective of the course is to upgrade the student's fundamental knowledge to cope with complex problems associated with the heat and mass transfer in thermal and process engineering. The course improves the ability of independent learning, personal and professional growth and provides the basis for understanding transport phenomena, which is a necessity for the comprehension of the mechanisms of heat and mass transfer. The content and the manner of the course allows and stimulates autonomous learning; fosters independent thinking and provides a basis for independent research work. **Competences:** Student gains new skills and upgrades the previously acquired knowledge for modeling transport phenomena. Furthermore, the student studies cases, which provide knowledge and practical experience for managing computer tools required for simulation of fluid flow conditions, temperature and concentration fields in the heat and mass transfer in thermal and process engineering. Student will aquire practical experience and results with experimental laboratory work on the pilot plants, which will enable the verification of the outcome of simulations.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Glavni cilj predmeta je nadgradnja temeljnih znanj študentov za obvladovanje kompleksnih problemov povezanih s prenosom toplote in snovi v	The main objective of the course is to upgrade the student's fundamental knowledge to cope with complex problems associated with the heat and

toplotni in procesni tehniki. Predmet razvija sposobnost samostojnega učenja, osebne in profesionalne rasti ter daje osnovo za razumevanje transportnih pojavov, ki so predpogoj za popis mehanizmov prenosa toplote in snovi. Vsebina in način izvedbe predmeta omogoča avtonomno učenje in utrjevanje samostojnega razmišljanja ter daje podlago za samostojno raziskovalno delo. Študent osvoji nova znanja in nadgradi že pridobljena znanja za modeliranje transportnih pojavov. Nadalje študent na konkretnih primerih pridobi znanje in praktične izkušnje za obvladovanje računalniških orodij za simulacijo tokovnih in temperaturnih razmer ter polja koncentracij pri prenosu toplote in snovi v elementih toplotne in procesne tehnike. Študent si z eksperimentalnim laboratorijskim delom na pilotnih napravah pridobi praktične izkušnje in rezultate za preverjanje rezultatov simulacij.	mass transfer in thermal and process engineering. The course improves the ability of independent learning, personal and professional growth and provides the basis for understanding transport phenomena, which is a necessity for the comprehension of the mechanisms of heat and mass transfer. The content and the manner of the course allows and stimulates autonomous learning; fosters independent thinking and provides a basis for independent research work. Student gains new skills and upgrades the previously acquired knowledge for modeling transport phenomena. Furthermore, the student studies cases, which provide knowledge and practical experience for managing computer tools required for simulation of fluid flow conditions, temperature and concentration fields in the heat and mass transfer in thermal and process engineering. Student will aquire practical experience and results with experimental laboratory work on the pilot plants, which will enable the verification of the outcome of simulations.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Predavanja, laboratorijske vaje, seminarsko delo, e-izobraževanje, konzultacije. Seminarsko delo v čim večji meri navezujoče se na področje doktorskega raziskovanja. Študij z uporabo priporočene literature.	Lectures, laboratory practice & seminar work, e-education, consulting. The seminar work is related, as much as possible, to the student's doctoral research field. Study on a recommended literature basis.

Načini ocenjevanja:	**Delež/ Weight**	**Assessment:**
Način (pisni izpit, ustno izpraševanje, naloge) Ustni izpit, poročilo o seminarskem delu, naloge. Pogoj za opravljanje ustnega izpita je uspešno izdelano in pozitivno ocenjeno seminarsko delo: • seminarsko delo 30% • naloge 30% • ustni izpit 40%		Method (written exam, oral examination, assignments, project) Oral exam, report on seminar work. The condition for admission to oral exam is successful completion of seminar work, rewarded with a passing grade. • project seminar (30%) • assignments (30%) •

		oral examination (40%)

Reference nosilca/Lecturer's references:

prof.dr. Andrej KITANOVSKI

LORBEK, Luka, POREDOŠ, Primož, KITANOVSKI, Andrej, POREDOŠ, Alojz. Analytical modeling and numerical simulation of heat transfer in a skin evaporator. *International journal of refrigeration*, ISSN 0140-7007. [Print ed.], 2018, str. [1-19], ilustr. https://www.sciencedirect.com/science/article/pii/S0140700718300318, doi: 10.1016/j.ijrefrig.2018.01.012. [COBISS.SI-ID 15891227],

TOMC, Urban, TUŠEK, Jaka, KITANOVSKI, Andrej, POREDOŠ, Alojz. A numerical comparison of a parallel-plate AMR and a magnetocaloric device with embodied micro thermoelectric thermal diodes. *International journal of refrigeration*, ISSN 0140-7007. [Print ed.], 2014, vol. 37, str. 185-193, ilustr., doi: 10.1016/j.ijrefrig.2013.07.003. [COBISS.SI-ID 13046555]

TUŠEK, Jaka, KITANOVSKI, Andrej, POREDOŠ, Alojz. Geometrical optimization of packed-bed and parallel-plate active magnetic regenerators. *International journal of refrigeration*, ISSN 0140-7007. [Print ed.], 2013, vol. 36, iss. 5, str. 1456-1464, ilustr., doi: http://dx.doi.org/10.1016/j.ijrefrig.2013.04.001. [COBISS.SI-ID 12954395]]

NIELSEN, Kaspar K., TUŠEK, Jaka, ENGELBRECHT, Kurt, SCHOPFER, S., KITANOVSKI, Andrej, BAHL, Christian Robert Haffenden, SMITH, Anders, PRYDS, Nini, POREDOŠ, Alojz. Review on numerical modeling of active magnetic regenerators for room temperature applications. International journal of refrigeration, ISSN 0140-7007. [Print ed.], May 2011, vol. 34, iss. 3, str. 603-616, doi: 10.1016/j.ijrefrig.2010.12.026. [COBISS.SI-ID 11767323]]

EGOLF, Peter W., KITANOVSKI, Andrej, ATA-CAESAR, Derrick, STAMATIOU, Evangelos, KAWAJI, Masahiro, BEDECARRATS, Jean-Pierre, STRUB, Francoise. Thermodynamics and heat transfer of ice slurries. *International journal of refrigeration*, ISSN 0140-7007. [Print ed.], 2005, letn. 28, št. 1, str. 51-59. http://www.sciencedirect.com/science/journal/01407007. [COBISS.SI-ID 7833627]

ŠARLAH, Alen, POREDOŠ, Alojz, KITANOVSKI, Andrej, EGOLF, Peter W. Prenos toplote v toku ledene brozge = Heat transfer in an ice-slurry flow. *Strojniški vestnik*, ISSN 0039-2480, 2005, letn. 51, št. 1, str. 3-12. [COBISS.SI-ID 8034843]

EGOLF, Peter W., KITANOVSKI, Andrej, ATA-CAESAR, D., VUARNOZ, Didier. Cold storage with ice slurries. *International journal of energy research*, ISSN 0363-907X, 2008, vol. 32, iss. 3, str. 187-203, doi: 10.1002/er.1340. [COBISS.SI-ID 11241755]