OBDELOVALNI STROJI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	OBDELOVALNI STROJI
Course title:	MACHINE TOOLS
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo, tretja stopnja, doktorski	Proizvodno inženirske znanosti, kibernetika in mehatronika (smer)	1. letnik, 2. letnik	Celoletni	izbirni

Univerzitetna koda predmeta/University course code:	0033461
Koda učne enote na članici/UL Member course code:	7306

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:	Franci Pušavec

Izvajalci predavanj:	Tomaž Pepelnjak, Franci Pušavec
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):**
Optimalni pristop h konstruiranju obdelovalnih strojev po 3 E načelu (ekonomičnost, ergonomičnost, estetika). Izbira in preračun temeljev in ogrodja stroja glede na namembnost. Konstrukcijsko izvedeni prijemi za zmanjšanje hrupa. Izvedbe vodil in vležajenj glede na zahteve stroja (groba obdelava, fina obdelava, visokoprecizna obdelava). Vrste pogonov in izbira med sodobnimi izvedbami (AC, linearni motorji, itd.). Upoštevanje in nadziranje geometričnih zahtev stroja - izdelka, statična, dinamična togost. Nadgradnja osnovne teorije s teorijo trajnostnega razvoja in tako pri načrtovanju stroja paralelno vključevati rešitve v povezavi z ekologijo, varnostjo pri delu, itd.	Optimum ways in machine tool construction according to 3 E methodology (economical, ergonomic, esthetical). Defining and calculation of machine tool bases, machine tool housing in correlation to the machine tool requirements. The ways to find the solution for decreasing the noise in the stage of machine tool construction. Defining the slide ways and bearing system with their realization in correlation to machine tool requirements (rough machining, fine machining, and high precision machining). Sorts of drives and their usage in state of the art machine tools (AC, linear motors, etc.). Control of geometrical requirements and taking them into account when developing machine tool – product, statical and dynamical stiffness. Upgrade of basic theory of machine tool development with theory of sustainable development, and so in development of machine tool in parallel include ecology, safety, etc.

Temeljna literatura in viri/Readings:

[1] Energy efficient manufacturing: theory and applications. Hoboken (NJ); Beverly (MA): Wiley; Scrivener Publishing, 2018, str. XIV, 451. ISBN 978-1-118-42384-4, [COBISS.SI-ID 158647811]
[2] Modern manufacturing processes. Hoboken (NJ): Wiley, 2020, str. XXI, 514. ISBN 978-1-118-07192-2, [COBISS.SI-ID 149649411]
[3] M. P. Groover, Fundamentals of modern manufacturing: materials, processes, and systems, 7th ed. Hoboken (NJ): John Wiley & Sons, 2020, str. XIV, 703, 71, 14. ISBN 978-1-119-72201-4, [COBISS.SI-ID 146641667]

[4] J. Kopač, Odrezavanje: teoretične osnove in tehnološki napotki. Ljubljana [i. e.] Domžale: [samozal.] J. Kopač, 2008, str. 264. ISBN 978-961-245-583-5, [COBISS.SI-ID 241209856]
[5] Z. Bi in X. Wang, Computer aided design and manufacturing. Hoboken, NJ; [New York, New York]: John Wiley & Sons, Inc.; ASME Press, 2020, str. XXI, 18 f., 617. ISBN 978-1-119-53421-1, [COBISS.SI-ID 44464899]
[6] Kuzman, K. (1988). Tehnološke karakteristike preoblikovalnih strojev (Ponatis 1. izd., str. V, 36 f.). Fakulteta za strojništvo., COBISS.SI-ID – 7185920
[7] Kampuš, Z., & Kuzman, K. (2016). Priporočila preoblikovanja (2. izd., str. IV, 78). Fakulteta za strojništvo., COBISS.SI-ID – 283051776
[8] Hosford, W. F., & Caddell, R. M. (2007). Metal forming: mechanics and metallurgy (3rd ed., str. XIII, 312). Cambridge University Press. http://www.loc.gov/catdir/toc/ecip0712/2007008558.html, COBISS.SI-ID – 10256923
[9] Montgomery, D. C. (2005). Design and analysis of experiments (6th ed., str. XV, 643). J. Wiley & Sons., COBISS.SI-ID – 1495462
[10] Injection molding handbook (str. XVII, 748). (2002). C. Hanser Verlag; Hanser Gardner Publications., COBISS.SI-ID – 4936475

Cilji in kompetence:	**Objectives and competences:**
Cilji: Osnovna načela strojegradnje; značilnosti pri konstruiranju strojev z zagotavljanjem karakteristik b-m-k (dušilnost – masa – togost). Pristop k modulnemu načrtovanju strojev z vključevanjem tržno dosegljivih enot. Seznanitev s posameznimi moduli kot so: temelji stroja, energetska enota, prenosniki, ohišja, vodila, itd. Značilnice strojev kot so stroji z definirano in nedefinirano geometrijo odrezka, večoperacijski obdelovalni centri, mehanske in hidravlične stiskalnice, stroji za tlačno litje, za injekcijsko brizganje polimernih gradiv, itd. Preizkušanje strojev, kontrola natančnosti, statična in dinamična togost, delovna natančnost. Koncipiranje, oblikovanje in konstruiranje izven standardnih strojev in orodij. Dinamika in kinematika strojev, nadzor - senzorika strojev; povezava stroj-orodja-izdelek. Sodobni načini upravljanja in krmiljenja strojev. **Kompetence:** - Obvladovanje pristopov k konstruiranju obdelovalnih strojev	**Goals:** The basic principles of machine tool construction and its development is going to be presented; properties in machine tool construction for reaching d-m-k characteristics (damping – mass – stiffness). The way to modular machine tool construction, using market available parts. Make students familiar with individual modules, such as: machine tool base, energetic unit, housings, machine ways, etc. Machine tool characteristics as machine tools with defined and undefined chip geometry, multi-operational machining centers, mechanical and hydraulic presses, forging machine tools, machine tools for injection molding of plastic, etc. Testing of machine tool, precision controlling, statical and dynamical stiffness, working precision with reputability. Conception, design and construction non-standard machine tools and tools. Machine tool dynamics and kinematics, machine tool control with sensors; machine tool-tool-workpiece relation. Modern ways of machine tool control and direction. **Competences:** - Be acquainted with principles to

- Obvladovanje konstrukcijskih prijemov za zmanjšanje hupa, vibracij, itd. pri obdelovalnih strojih - Obvladovanje preračunavanje pogonov obdelovalnih strojev - Obvladovanje kontrole geometričnih zahtev obdelovalnih strojev - Sposobnost vključevanja idej trajnostnega razvoja pri snovanju obdelovalnih strojev	construct the machine tool - Be acquainted with solutions for decreasing the noise, vibration, etc. of machine tools - Be acquainted with calculation of machine tool drives - Be acquainted with machine geometrical precision checking - Be capable of application of sustainable development ideas in machine tool construction planning

Predvideni študijski rezultati:	**Intended learning outcomes:**
- Obvladovanje pristopov k konstruiranju obdelovalnih strojev - Obvladovanje konstrukcijskih prijemov za zmanjšanje hupa, vibracij, itd. pri obdelovalnih strojih - Obvladovanje preračunavanje pogonov obdelovalnih strojev - Obvladovanje kontrole geometričnih zahtev obdelovalnih strojev - Sposobnost vključevanja idej trajnostnega razvoja pri snovanju obdelovalnih strojev	Knowledge and understanding: Be acquainted with principles to construct the machine tool - Be acquainted with solutions for decreasing the noise, vibration, etc. of machine tools - Be acquainted with calculation of machine tool drives - Be acquainted with machine geometrical precision checking - Be capable of application of sustainable development ideas in machine tool construction planning

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:**
Ustni izpit, poročilo o seminarskem delu. Pogoj za opravljanje ustnega izpita je uspešno izdelano in pozitivno ocenjeno seminarsko delo. • seminarsko delo		Oral exam, report on seminar work. The condition for admission to oral exam is successful completion of seminar work, rewarded with a passing grade. •

(60%) • ustno izpraševanje (40%)		seminar work (60%) • oral examination (40%)

Ocenjevalna lestvica:	**Grading system:**

Reference nosilca/Lecturer's references:

prof. dr. Franci PUŠAVEC

DUGAR, Jaka, IKRAM, Awais, KLOBČAR, Damjan, PUŠAVEC, Franci. Sustainable hybrid manufacturing of AlSi5 alloy turbine blade prototype by robotic direct energy layered deposition and subsequent milling : an alternative to selective laser melting?. Materials. Dec. 2022, vol. 15, no. 23, str. 1-39, ilustr. ISSN 1996-1944. https://www.mdpi.com/1996-1944/15/23/8631, https://repozitorij.uni-lj.si/IzpisGradiva.php?id=144948, DOI: 10.3390/ma15238631. [COBISS.SI-ID 146512387]

ROBLEK, Vasja, MEŠKO, Maja, PUŠAVEC, Franci, LIKAR, Borut. The role and meaning of the digital transformation as a disruptive innovation on small and medium manufacturing enterprises. Frontiers in psychology. 2021, vol. 12, art. 592528, str. 1-18, ilustr. ISSN 1664-1078. https://www.frontiersin.org/articles/10.3389/fpsyg.2021.592528/full, https://repozitorij.uni-lj.si/IzpisGradiva.php?id=144662. [COBISS.SI-ID 66328835],

GRGURAŠ, Damir, STERLE, Luka, KRAJNIK, Peter, PUŠAVEC, Franci. A novel cryogenic machining concept based on a lubricated liquid carbon dioxide. International journal of machine tools & manufacture. [Print ed.]. Oct. 2019, vol. 145, str. 1-6, ilustr. ISSN 0890-6955. https://www.sciencedirect.com/science/article/pii/S0890695519307953?via%3Dihub, https://repozitorij.uni-lj.si/IzpisGradiva.php?id=126432, DOI: 10.1016/j.ijmachtools.2019.103456. [COBISS.SI-ID 16781851]

KRAJNIK, Peter, RASHID, Amir, PUŠAVEC, Franci, REMŠKAR, Maja, YUI, Akinori, NIKKAM, Nader, TOPRAK, Muhammet. Transitioning to sustainable production. Pt. 3, Developments and possibilities for integration of nanotechnology into material processing technologies. Journal of cleaner production. [Print ed.]. Jan. 2016, vol. 112, pt. 1, str. 1156-1164, ilustr. ISSN 0959-6526. DOI: 10.1016/j.jclepro.2015.08.064. [COBISS.SI-ID 14444315]

izr. prof. dr. Tomaž Pepelnjak

PEPELNJAK, Tomaž, KARIMI, Ako, MAČEK, Andraž, MOLE, Nikolaj. Altering the elastic properties of 3D printed poly-lactic acid (PLA) parts by compressive cyclic loading. *Materials*. Oct. 2020, vol. 13, iss. 19, f. 1-18, ilustr. ISSN 1996-1944. https://www.mdpi.com/1996-1944/13/19/4456/htm, DOI: 10.3390/ma13194456. [COBISS.SI-ID 32536579]

BORIĆ, Andrej, KALENDOVÁ, Alena, URBANEK, Michal, PEPELNJAK, Tomaž. Characterisation of polyamide (PA)12 nanocomposites with montmorillonite (MMT) filler clay used for the incremental forming of sheets. *Polymers*. Jul. 2019, vol. 11, iss. 8, f. 1-15, ilustr. ISSN 2073-4360. https://www.mdpi.com/2073-4360/11/8/1248/pdf, DOI: 10.3390/polym11081248. [COBISS.SI-ID 16803611]

SATOŠEK, Roman, PEPELNJAK, Tomaž, STARMAN, Bojan. Characterisation of out-of-plane shear behaviour of anisotropic sheet materials based on indentation plastometry. *International journal of mechanical sciences*. Apr. 2023, str. 1-24, ilustr. ISSN 0020-7403. https://www.sciencedirect.com/science/article/pii/S0020740323003053, DOI: 10.1016/j.ijmecsci.2023.108403. [COBISS.SI-ID 149875203]

PEPELNJAK, Tomaž, ŠAŠEK, Patricia, KUDLÁČEK, Jan. Upsetting analysis of high-strength tubular specimens with the Taguchi method. *Metals*. Nov. 2016, vol. 6, iss. 11, f. 1-14, ilustr. ISSN 2075-4701. http://www.mdpi.com/2075-4701/6/11/257/html, DOI: 10.3390/met6110257. [COBISS.SI-ID 15008283]