UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Računalniško modeliranje geometrije
Course title:	Computer aided modelling of geometry
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Ni členitve (študijski program)	1. letnik	2. semester

Univerzitetna koda predmeta/University course code:	0562664
Koda učne enote na članici/UL Member course code:	3009-V

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

Nosilec predmeta/Lecturer:	Damijan Zorko, Leon Kos, Nikola Vukašinović
Vrsta predmeta/Course type:	Obvezni splošni predmet /Compulsory general 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. Predavanje: Uvod v 3D modeliranje - Opredelitev 3D modeliranja, - Osnove računalniške grafike, - Opredelitev 3D prostora, - koordinatni sistemi, - osnove 3D geometrije. 2. Predavanje: Modeliranje v 3D prostoru - Razvoj modeliranja in modelirnikov, - Predstavitev modeliranja trdnih modelov, - Lastnosti trdnih modelov, - Načini zapisa in dela s trdnimi modeli.	1. Lecture: Introduction into 3D modelling: - Definition of 3D modelling, - Basics of computer graphics, - Definition of 3D space in CAD, - Coordinate systems, - Basics of 3D geometry. 2. Lecture: Modelling in 3D space - Evolution of modelling and modellers, - Introduction into solid modelling, - Characteristics of solid models, - Various definitions of solid models.

3. Predavanje: Alternativni zapisi 3D modelov - Zapis 3D objektov z žičnimi modeli, - Zapis površinskih modelov, - Mnogokotniške mreže, - Polnjenje površin in odstranjevanje nevidnih robov. 4. Predavanje: Modeliranje s topološkimi elementi - Primeri zapisov osnovnih geometrijskih elementov, - Predstavitev topoloških elementov, - Zapis topoloških elementov v racionalno bazo podatkov, - Zapis topoloških elementov v hierarhično bazo podatkov, - Zapis topoloških elementov v relacijsko bazo podatkov. 5. Predavanje: Skiciranje v 3D modelirnikih - Pozicioniranje skic v prostor - Uporaba topoloških elementov za izdelavo osnovnih parametrov geometrije - Relacije med različnimi elementi skic – topološkimi gradniki. - Uporaba grafičnih podlag za izdelavo skic. 6. Predavanje: Uvod v modeliranje z značilkami - Modeliranje z značilkami, - Kaj so to značilke, primer uporabe, - Razlike med osnovnimi in izpeljanimi značilkami, - Značilke in vpliv na izdelek. 7. Predavanje: Modeliranje z značilkami - osnovne znacilke - Linijski izvlek - Krožni izvlek - Krivuljni izvlek - Prehodi 8. Predavanje: Modeliranje z značilkami - izpeljane značilke - Zaokrožitve - Posnetja - Zrcaljenje - Vzorčenje - Izvotlitev - Rebra 9. Predavanje: Modeliranje glede na tehnologijo izdelave - Varjene konstrukcije - Krivljenje pločevine - Ulitki 10. Predavanje: Modeliranje fizičnih objektov in parameterizacija - Meritve fizičnih modelov za rekonstruiranje - Modeli za vgradnjo (groba oblika – gabaritne in priključne mere) - Modeli za zagotavljanje funkcije (funkcionalna oblika) - Kopije modelov – digitalni dvojček (detajlna oblika) - Parameterizacija in družina izdelkov 11. Predavanje: Modeliranje sestavov	3. Lecture: Alternative 3D model definitions - Definition of 3D objects with wireframe models, - Boundary representation models, - Polygon meshes, - Surfaace filling and removing of invisible edges. 4. Lecture: Modelling with topological elements - Examples of definition of basic geometric elements, - Introduction of topological elements, - Recording of topological elements into a rational database model, - Recording of topological elements into a hierachic database model, - Recording of topological elements into a relational database model. 5. Lecture: Sketching in 3D modelers - Positioning sketches in space - Use of topological elements for definition of basic geometry parameters, - Relations between different elements of a sketch – topological building blocks, - Use of graphical backgrounds to extract sketches. 6. Lecture: Introduction into feature based modelling - Feature based modelling, - Definition of features, examples of use, - Differences between basic and applied features, - Relations between features and products. 7. Lecture: Feature based modelling – Basic Features - Extrude, - Revolve, - Sweep, - Loft. 8. Lecture: Feature based modelling – Applied Features - Fillets and roundings, - Chamfers, - Mirroring, - Patterns, - Shelling, - Ribs. 9. Lecture: Modelling and manufacturing technologies - Welded structures - Sheet metal products - Castings 10. Lecture: Modeling of physical objects and parameterisation - Measuring of physical objects for reconstruction - Models for instalation (course shape – overall and connection dimensions) - Functional models (functional shape) - Replicas – digital twins (detailed shape) - Parametrisation and product families 11. Lecture: Modelling of assemblies - Structure of a product and levels of design, - Assembly modelling: bottom-up approach,

- Struktura izdelka ter nivoji konstruiranja, - Tehnika modeliranja od spodaj navzgor, - Tehnika modeliranja od zgoraj navzdol. 12. Predavanje: Krivulje in zahtevnejše geometrije - Zahtevane lastnosti krivulj, - Bezierjeve krivulje in zlepki v praksi - Povezave med posameznimi krivuljami – zveznost ničelne, prve in druge stopnje. - Izpeljava iz krivulj v prostor ali površino. 13. Predavanje: Osnove modeliranja s površinami: - Izdelava površinskih modelov - Sestavljanje površin - Zveznosti med površinami - Tvorjenje trdnih modelov iz površin - Kombiniranje trdnih in površinskih modelov. 14. Predavanje: Tvorjenje tehnične dokumentacije iz 3D modelov - Kako tvorimo dokumentacijo - Določanje geometrijskih in dimenzijskih toleranc na modelu in načrtu - Določanje dodatnih konstrukcijskih pravil na 3D modelu in v dokumentaciji 15. Predavanje: Definiranje na osnovi 3D modela (Model Based Definition) - Izdelava dokumentacije neposredno na 3D modelu, - Načini prikazov in izvozov pri MBD, - Prehod iz MBD na papir, - Priprava in uporaba MBD za proizvodnjo.	- Assembly modelling: Top-down approach. 12. Lecture: Curves and complex geometries - Required characteristics of curves, - Bézier curves and splines in application - Relations between the curves – Continuity of zero-, first and second degree. - From curves into space or surface. 13. Lecture: Basics of surface modelling: - Creation of surface models - Combining of the surfaces - Continuity of the surfaces - Creation of solid models from surfaces - Combining of solid and surface models. 14. Lecture: Creation of technical drawings and documentation for 3D models - How to create documentation, - Determination of geometrical and dimensional tolerances on a model and on a drawing. - Annotation of additional design specifications on a 3D model and in documentation. 15. Lecture: Model Based Definition (MBD) - Design of documentation on a 3D model, - Different visualisation and exportation methods from MBD, - Transition from MBD to a sheet of paper, - Preparation and use of MBD for production purposes.

Temeljna literatura in viri/Readings:

1. Watt A (1990) Fundamentals of Three-dimensionals Computer Graphis, Addison Wesley, Boston
2. Farin GE (2002) Curves and Surfaces for Computer-Aided Geometric Design, Academic Press
3. Jankauskas K (2010) Time-efficient nurbs curve evaluation algorithms. In: Proceedings of the 16th international conference on Information and Software Technologies, p 60-69
4. Patrikalakis NM, Maekawa T (2002) Intersection problems. In: Farin GE, Kim M-S (ed) Handbook of Computer Aided Geometric Design. Elsevier doi: 10.1016/B978-044451104-1/50026-5
5. Bu-Qing S, Ding-Yuan L (1989) Computational Geometry: Curve and Surface Modeling. Academic Press
6. Petrišič J (1999) Interpolacija. Fakulteta za strojništvo, Ljubljana
7. Vukašinović N., Duhovnik J. (2019) Advanced CAD modeling, Springer, ISBN: 978-3-030-02398-0, DOI: 10.1007/978-3-030-02399-7
8. Duhovnik, J., Demšar, I., Drešar, P. Space modeling with SolidWorks and NX. Cham [etc.]: Springer, cop. 2015. XIV, 490 str., ilustr. ISBN 978-3-319-03861-2. ISBN 978-3-319-03862-9, doi: 10.1007/978-3-319-03862-9. [COBISS.SI-ID 13418011]
9. Duhovnik, J., Demšar, I., Drešar, P. Modeliranje z značilkami na osnovi SolidWorks. Prenovljena izd. Ljubljana: Fakulteta za strojništvo, 2017. VI, 274 str., ilustr. ISBN 978-961-6980-28-9. [COBISS.SI-ID 288756992]

Cilji in kompetence:	**Objectives and competences:**
Cilji: 1. Razumeti modeliranje kot delovni proces za zagotavljenje želenih funkcij izdelka z uporabo virtualne geometrije pri konstruiranju izdelkov.	Objectives: 1. Understand modelling as a work process to provide desired product features using virtual geometry in

2. Spoznati povezavo med procesom konstruiranja, procesom 3D modeliranja in tehnološkimi procesi izdelave izdelka. 3. Spoznati in samostojno uporabljati razpoložljive orodja in naprave, ki omogočajo predstavitev izdelkov v 3D prostoru. 4. pridobiti dobro poznavanje vsaj enega CAD modelirnika z njegovimi karakteristikami. 5. Spoznati načine za predstavitev 3D modelov in potrebnih informacij o izdelku v 3D okolju, ter prenos informacij med modelirniki in v 2D prostor. Kompetence: 1. S1-PAP + P8-PAP: Obvladovanja virtualnega 3D prostora, kot delovnega okolja sodobnih inženirskih znanosti. 2. S1-PAP + P9-PAP: Dobra 3D predstava konstrukcijskih objektov in sposobnost razumevanja medsebojnih povezav in vplivov posameznih elemenov v prostoru. 3. S10-PAP, S12-PAP+P3PAP: Sposobnost samostojnega inženirskega komuniciranja z uporabo 3D modelov in iz njih izpeljanih risb ter druge dokumentacije. 4. S12-PAP + P7-PAP: Usposobljenost za rutinsko uporabo najmanj enega modelirnika ter razumevanje delovanja večine sodobnih modelirnikov z minimalno potrebno priučitvijo za njihovo rutinsko uporabo.	product design. 2. To learn the connection between the design process, the 3D modelling process and the technological processes of product manufacturing. 3. To learn about and use independently the available tools and devices that enable the presentation of products in 3D space. 4. gain a good knowledge of at least one CAD modeler with its characteristics. 5. Learn methods to present 3D models and required product information in a 3D environment, and transfer information between modelers and 2D space. Competences: 1. S1-PAP + P8-PAP: The ability to work in virtual 3D space as a working environment of modern engineering sciences. 2. S1-PAP + P9-PAP: Good 3D understanding of design objects and ability to understand mutual relations and influences among different elements in space. 3. S10-PAP, S12-PAP+P3PAP: Ability of proficient engineering communication using 3D models and their drawings and other documentation. 4. S12-PAP + P7-PAP: Use of at least one 3D modeller and principle understanding of most of modern modeller with minimal required training for their routine use.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanja: Z1: Poglobljeno strokovno teoretično in praktično znanje na določenem področju, podprto s širšo teoretično in metodološko osnovo: • Poglobljeno strokovno in teoretično znanje s področja računalniškega modeliranja geometrije (CAD) • Poglobljeno razumevanje delovanja CAD modelirnikov • Poglobljeno razumevanje principov izdelave tehničnih konstrukcij in sistemov ter njihove 3D in 2D predstavitve. Spretnosti: S1.1 Izvajanje kompleksnih operativno-strokovnih opravil, ki vključujejo tudi uporabo metodoloških orodij: • Sposobnost sistemskega pristopa pri izdelavi 3D modelov konstrukcij in geometrijskemu razvoju izdelkov. S1.2 Obvladovanje zahtevnih, kompleksnih delovnih procesov ob samostojni uporabi znanja v novih delovnih situacijah: • razumevanje in sposobnost samostojne uporabe 3D modeliranja za potrebe reševanja osnovnih inženirskih	Knowledge: Z1: In-depth professional theoretical and practical knowledge in the specific field, supported by a wide theoretical and methodological basis: • In-depth expertise in theoretical knowledge of computer-aided geometry modeling (CAD) • In-depth understanding of CAD modelers • In-depth understanding of the principles of technical structures and systems and their 3D and 2D presentation. Skills: S1.1 Performance of complex operational and specialist tasks, including the use of methodological tools: • Ability to take a systematic approach to 3D model construction and geometric product development. S1.2 Handling difficult, complex working priciples by independent application of knowledge in new working situations: • understanding and ability to independently use 3D modeling for solving basic engineering design problems.

konstrukcijskih problemov.	

Metode poučevanja in učenja:	**Learning and teaching methods:**
P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov. P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki. P4 Laboratorijske vaje z namenskimi didaktičnimi pripomočki: • Računalniške delovne postaje s programskimi paketi za modeliranje • Uporaba VR opreme pri modeliranju P15 Uporaba video vsebin kot priprava na vaje P12 Individualizirane domače naloge v spletni učilnici	P1 Auditory lectures with solving selected and typical theoretical and practical examples. P2 Presentation of a subject matter based on the arranged and previously explained scheme. P4 Laboratory exercises with dedicated didactic aids: • Computer workstations with software packages for modeling • Use of VR equipment for modelling P15 use of video contents for excersise preparations. P12 Individual homework assignments in a virtual classroom.

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
- Teoretične vsebine (predavanja):	50,00 %	- Teoretical contents (lectures):
- Samostojno delo v laboratoriju:	50,00 %	- Independent laboratory work:

Reference nosilca/Lecturer's references:

Nikola Vukašinović

1. **VUKAŠINOVIĆ, Nikola**, BRAČUN, Drago, MOŽINA, Janez, DUHOVNIK, Jože. The influence of incident angle, object colour and distance on CNC laser scanning. The international journal of advanced manufacturing technology, ISSN 0268-3768, Sep. 2010, vol. 50, iss. 1/4, str. 265-274, ilustr., doi: 10.1007/s00170-009-2493-x. [COBISS.SI-ID 11254299]
2. **VUKAŠINOVIĆ, Nikola**, KOLŠEK, Tomaž, DUHOVNIK, Jože. Case study - surface reconstruction from point clouds for prosthesis production. Journal of engineering design, ISSN 0954-4828. [Print ed.], 2007, letn. 18, št. 5, str. 475-488. http://www.tandf.co.uk/journals. [COBISS.SI-ID 10172187], [JCR, SNIP, WoS do 2 4. 2018: št. citatov (TC): 9, čistih citatov (CI): 7, Scopus do 20. 11. 2018: št. citatov (TC): 10, čistih citatov (CI): 8]
3. URBAS, Uroš, VRABIČ, Rok, **VUKAŠINOVIĆ, Nikola**. Displaying product manufacturing information in augmented reality for inspection. V: BUTALA, Peter (ur.), GOVEKAR, Edvard (ur.), VRABIČ, Rok (ur.). 52nd CIRP Conference on Manufacturing Systems (CMS), Ljubljana, Slovenia, June 12-14, 2019, (Procedia CIRP, ISSN 2212-8271, vol. 81). Amsterdam: Elsevier. 2019, vol. 81, f. 832-837, ilustr. https://www.sciencedirect.com/science/article/pii/S221282711930513X, doi: 10.1016/j.procir.2019.0208. [COBISS.SI-ID 16675611], [SNIP, Scopus do 18. 7. 2019: št. citatov (TC): 0, čistih citatov (CI): 0]
4. ŽAVBI, Roman, **VUKAŠINOVIĆ, Nikola**. A concept of academia-industry collaboration to facilitate the building of technical and professional competencies in new product development. International journal of engineering education, ISSN 0949-149X, 2014, vol. 30, no. 6, str. 1562-1578, ilustr. [COBISS.SI-ID 13757979]
5. ANIĆ, Dino, ANTONIĆ, Krunoslav, DUHOVNIK, Jože, MARLOT, Jernej, PAVKOVIĆ, Neven, PENCA, Jure, POVŠE, Gregor, SOFALVI, Janos, SZABO, Joszef, TADEJ, Tea, **VUKAŠINOVIĆ, Nikola**. Handküchengerät mit Schutzabdeckung : EP2394544 (B1), 2014-05-21. München: Europäisches Patentamt, 2014. 11 f., ilustr. [COBISS.SI-ID 12127259]

Leon Kos

1. **KOS, Leon**, PITTS, Richard, SIMIČ, Gregor, BRANK, Matic, ANAND, H., ARTER, W. SMITER: a field-line tracing

environment for ITER. Fusion engineering and design, ISSN 0920-3796. [Print ed.], Sep. 2019, vol. 146, pt. B, str. 1796-1800, doi: 10.1016/j.fusengdes.2019.03.037.

2. **KOS, Leon**, KULOVEC, Simon, ZALETELJ, Viktor, DUHOVNIK, Jože. Structure generation for free-form architectural design. Advanced engineering, 2009, vol. 3, no. 2, str. 187-194
3. FALCHETTO, G. L., **KOS, Leon**, KULOVEC, Simon, et al. The European Integrated Tokamak Modelling (ITM) effort : achievements and first physics results. Nuclear fusion, ISSN 0029-5515, Apr. 2014, vol. 54, no. 4, 19 str., doi: 10.1088/0029-5515/54/4/043018.
4. TSKHAKAYA, D. D., **KOS, Leon**, JELIĆ, Nikola. A unified analysis of plasma-sheath transition in the Tonks-Langmuir model with warm ion source. Physics of plasmas, ISSN 1070-664X, Jul. 2014, vol. 21, iss. 7, str. [1]-[12], doi: 10.1063/1.4885638.
5. **KOS, Leon**, TSKHAKAYA, D. D., KUHN, Siegbert, JELIĆ, Nikola. Debye-sheath properties in the Tonks-Langmuir discharge with warm neutrals. Journal of plasma physics, ISSN 0022-3778, Dec. 2013, vol. 79, no. 6, str. 1021-1024., doi: 10.1017/S0022377813000949.

Damijan Zorko

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2. TAVČAR, Jože, ČERNE, Borut, DUHOVNIK, Jože, **ZORKO, Damijan**. A multicriteria function for polymer gear design optimization. Journal of computational design and engineering, ISSN 2288-4300, 2021, str. 1-19, ilustr. https://academic.oup.com/jcde/advancearticle/ doi/10.1093/jcde/qwaa097/6097077?guestAccessKey=e43f29f2-a55f-42d4-a526-b10df331be86, doi: 10.1093/jcde/qwaa097 [COBISS.SI-ID 47172355], [JCR, SNIP, WoS do 22. 10. 2021: št. citatov (TC): 5, čistih citatov (CI): 1, čistih citatov na avtorja (CIAu): 0.50, Scopus do 17. 11. 2021: št. citatov (TC): 5, čistih citatov (CI): 2, čistih citatov na avtorja (CIAu): 1.00] kategorija: 1A1 (Z, A', A1/2); uvrstitev: SCI, Scopus, MBP; tip dela je verificiral OSICT točke: 64.54, št. avtorjev: 4/4
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4. HLEBANJA, Gorazd, KULOVEC, Simon, **ZORKO, Damijan**, HLEBANJA, Jože, DUHOVNIK, Jože. Influence of the tooth flank shape on thermal load of the gear. V: Europe invites the world, International Conference on Gears, International Conference on Gear Production, International Conference on High Performance Plastic Gears, Technische Universität München, Garching, September 13th to 15th, 2017, (VDI-Berichte, ISSN 0083-5560, 2294.2). Düsseldorf: VDI. 2017, str. 1583-1592, ilustr. [COBISS.SI-ID 15663899], [WoS do 26. 8. 2021: št. citatov (TC): 5, čistih citatov (CI): 2, čistih citatov na avtorja (CIAu): 0.40] kategorija: SU (S); tip dela je verificiral OSICT točke: 1, št. avtorjev: 3/5
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