

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Inženiring površin in kontaktov
Course title:	Surface and contact engineering
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Strojništvo - Razvojno raziskovalni program, druga stopnja, magistrski	Konstruiranje (smer)	1. letnik	1. semester

Univerzitetna koda predmeta/University course code: 0566872

Koda učne enote na članici/UL Member course code: 6025-M

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
30		30			65	5

Nosilec predmeta/Lecturer: Mitjan Kalin

Vrsta predmeta/Course type: Obvezni strokovni predmet na smeri Konstruiranje, ki je izbirni strokovni predmet na ostalih smereh./Compulsory specialised course in the study of Design Engineering, which is an elective specialised course in other fields of study.

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

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti: **Prerequisites:**

Izpolnjevanje pogojev za vpis v Magistrski študijski program II. stopnje Strojništvo - Razvojno raziskovalni program.	Meeting the enrollment conditions for the Master's study programme of Mechanical Engineering - Research and Development program.
---	--

Vsebina: **Content (Syllabus outline):**

1. Predavanja: - Značilnosti inženirskih površin, fizikalno-kemijske lastnosti površin, topografija, napredni parametri površin, standardi za metrologijo površin, lastnosti na več skalah.	1. Lecture: - Properties of engineering surfaces, physio-chemical surface properties, topography, advanced surface parameters, surface metrology standards, multi-scale properties.
--	--

<p>2. Predavanje:</p> <ul style="list-style-type: none"> - Realna kontaktna površina: topografija in vršički, Deterministični modeli, statistični modeli, GW model, sodobne teorije, indeks plastičnosti. <p>3. Predavanje:</p> <ul style="list-style-type: none"> - Obličenje površin: teorija, izdelava, vrste, oblike, značilnosti, režimi mazanja, prednosti, slabosti, modeliranje. <p>4. Predavanje:</p> <ul style="list-style-type: none"> - Kontaktna temperatura: osnove kontaktnih temperatur, enačbe za kontaktne primere, meritve kontaktnih temperatur, empirični modeli, kompleksni modeli. <p>5. Predavanje:</p> <ul style="list-style-type: none"> - Mehanika mikro kontaktov: adhezija, JKR model kontakta, DMT model kontakta, Maguis model kontaktov <p>6. Predavanje:</p> <ul style="list-style-type: none"> - Modeliranje kontaktov (delavnica): praktični primeri določevanja realne kontaktne površine za inženirske sisteme. <p>7. Predavanje:</p> <ul style="list-style-type: none"> - Materiali za kontakte v inženirskih sistemih: kovine, polimeri, keramika, kompoziti. Lastnosti, prednosti, tribološke značilnosti. Mazanje. <p>8. Predavanje:</p> <ul style="list-style-type: none"> - Postopki inženiringa površin: osnovni postopki. Termični, kemijski, fizikalni, mehanski. Značilnosti, lastnosti, prednosti, slabosti. <p>9. Predavanje:</p> <ul style="list-style-type: none"> - Uporaba inženiringa površin: vrste in izdelava površinskih prevlek za obrabno odpornost, za nizko trenje, za korozijsko zaščito. <p>10. Predavanje:</p> <ul style="list-style-type: none"> - Značilnosti površinskih prevlek za tribološke aplikacije: značilnosti prevlek, struktura, napetosti in deformacije, večplastnost, mehanske lastnosti, hrapavost, defekti, razpoke, debelina, mazanje, tribološke lastnosti. <p>11. Predavanje:</p> <ul style="list-style-type: none"> - Karakterizacija površinskih prevlek: karakterizacija prevlek, optimizacija prevlek, izbor, uporaba. <p>12. Predavanje:</p> <ul style="list-style-type: none"> - Kontakti v industrijskih procesih: preoblikovanje, odrezavanje, valjanje, iztiskovanje, vlečenje, kovanje, ukrivljanje. <p>13. Predavanje:</p> <ul style="list-style-type: none"> - Kontakti v strojnih elementih in sistemih: kotalni ležaji, drsni ležaji, zobniki, tesnila, zavore, vetrne turbine, motorji z notranjim zgorevanjem, turbine, kompresorji. <p>14. Predavanje:</p> <ul style="list-style-type: none"> - Kontaktni inženiring za tribološke rešitve (viharjenje): analiza sistema, možnosti, koncepti, meritve, izvedba, mape, rešitve, uporaba. Primer. <p>15. Predavanje:</p>	<p>2. Lecture:</p> <ul style="list-style-type: none"> - Real contact area: topography and asperities, deterministic models, statistical models, GW model, modern theories, plasticity index. <p>3. Lecture:</p> <ul style="list-style-type: none"> - Surface texturing: theory, manufacturing, types and shapes, properties, lubrication regimes, advantages and disadvantages, modelling. <p>4. Lecture:</p> <ul style="list-style-type: none"> - Contact temperature: basics, equations for different cases, measurements, empirical models, complex models. <p>5. Lecture:</p> <ul style="list-style-type: none"> - Micro-contact mechanics: adhesion, DMT, JKR and Maguis models. <p>6. Lecture:</p> <ul style="list-style-type: none"> - Contact modelling (workshop): practical cases of real contact area in engineering systems. <p>7. Lecture:</p> <ul style="list-style-type: none"> - Materials for engineering contacts: polymers, ceramics, composites. Properties, advantages, tribological properties and lubrication. <p>8. Lecture:</p> <ul style="list-style-type: none"> - Surface engineering procedures: basics. Thermal, chemical, physical, mechanical. Properties, advantages, disadvantages. <p>9. Lecture:</p> <ul style="list-style-type: none"> - Surface engineering use: types and manufacturing of coatings for wear resistance, low friction, corrosion protection. <p>10. Lecture:</p> <ul style="list-style-type: none"> - Surface coatings properties for tribological applications: properties, structure, stresses and deformation, multi-layering, mechanical properties, roughness, defects, cracks, thickness, lubrication, tribological properties. <p>11. Lecture:</p> <ul style="list-style-type: none"> - Surface coating properties: characterisation, optimisation, selection and use. <p>12. Lecture:</p> <ul style="list-style-type: none"> - Contacts in manufacturing processes: drawing, cutting, rolling, injection moulding, pulling, smithing, curving. <p>13. Lecture:</p> <ul style="list-style-type: none"> - Contacts in machine elements and systems: roller bearings, sliding bearings, gears, seals, brakes, wind turbines, internal combustion engines, turbines, compressors. <p>14. Lecture:</p> <ul style="list-style-type: none"> - Contact engineering for tribological systems (brainstorming): system analysis, possibilities, concepts, measurements, realisation, maps, solutions, use. Example. <p>15. Lecture:</p>
--	--

- Aplikacije – primeri: primeri rešitev v avtomobilskih aplikacijah in industriji: ležaji, zavore, zobniki, odrezavanje in preoblikovanje, polimerni pogoni, visokotemperaturne aplikacije.	- Applications- examples: examples of solutions in automotive industry and applications: bearings, brakes, gears, drawing and cutting, polymer drives, high temperature applications.
---	---

Temeljna literatura in viri/Readings:

<ol style="list-style-type: none"> 1. K.L. Johnson: Contact mechanics, Cambridge University Press, 1985 2. I. Iliuc: Tribology of thin layers, Elsevier, 1980 3. F.W. Bach, A. Laarmann, T. Wenz: Modern Surface Technology, Wiley-vch, 2006 4. K. Holmberg: Coatings Tribology, Elsevier, 2009 5. C. Donnet, A. Erdemir: Tribology of diamond-like carbon films: fundamentals and applications, Springer, 2008
--

Cilji in kompetence:

<p>Cilji:</p> <ol style="list-style-type: none"> 1. Spoznati različne inženirske površine, možnosti obdelave in njihovo uporabo. 2. Spoznati in razumeti temeljne koncepte s področja inženirskih površin in kontaktov. 3. Spoznati različne površinske prevleke, njihovo karakterizacijo in uporabo. 4. Razumeti in znati analizirati inženirske kontakte glede na aplikacijo. <p>Kompetence:</p> <ol style="list-style-type: none"> 1. P2-MAG: Obvladovanje temeljnih teoretičnih znanj s področja inženiringa površin in kontaktov. 2. S1-MAG: Sposobnost razumevanja uporabe različnih inženirskih površin in prevlek. 3. S2-MAG + P1-MAG: Sposobnost razumevanja, vrednotenja in analize inženirskih kontaktov glede na aplikacijo. 4. S7-MAG + P7-MAG: Samostojna sinteza in modeliranje inženirskih kontaktov. 	<p>Goals:</p> <ol style="list-style-type: none"> 1. To get to know different engineering surfaces, surface processing options and their use. 2. To get to know and understand the basic concepts of engineering surfaces and contacts. 3. To get to know various surface coatings, their characterisation and use. 4. To understand and know how to analyse engineering contacts based on the applications. <p>Competences:</p> <ol style="list-style-type: none"> 1. P2-MAG: The basic theoretical knowledge of surface engineering and contacts. 2. S1-MAG: The ability to understand the use of various engineering surfaces and coatings. 3. S2-MAG + P1-MAG: The ability to understand, evaluate and analyse engineering contacts based on the application. 4. S7-MAG + P7-MAG: Independent synthesis and modelling of engineering contacts.
---	---

Predvideni študijski rezultati:

<p>Znanja:</p> <p>Z2: Poglobljeno teoretično, metodološko in analitično znanje z elementi raziskovanja s področja inženiringa površin in kontaktov.</p> <p>Spretnosti:</p> <p>S2.1 Razumevanje lastnosti in uporabe inženirskih površin in površinskih prevlek glede na aplikacijo.</p>	<p>Knowledge:</p> <p>Z2: In depth theoretical, methodological and analytical knowledge with research elements from the field of surface engineering and contacts.</p> <p>Abilities:</p> <p>S2.1 Understanding the properties and use of engineering surfaces and surface coatings based on</p>
---	--

S2.2 Samostojno načrtovanje in modeliranje inženirskih kontaktov.	the applications.
S2.3 Sposobnost vrednotenja in analize inženirskih površin in prevlek.	S2.2 Independent design and modelling of engineering contacts.
	S2.3 The ability to evaluate and analyse engineering surfaces and coatings.

Metode poučevanja in učenja:

Learning and teaching methods:

<p>P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.</p> <p>P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki.</p> <p>P3 Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri.</p> <p>P4 Laboratorijske vaje.</p> <p>P5 Uporaba študijskega gradiva v obliki (e-verzija predstavitve predavanj).</p> <p>P15 Uporaba video vsebin kot priprava na predavanja in vaje.</p>	<p>P1 Auditorial lectures, which include solving theoretical and practical examples relevant to the field.</p> <p>P2 Content teaching in an orderly and systematic fashion.</p> <p>P3 Auditorial tutorials, which upgrade the theoretical knowledge from the lectures with practical cases.</p> <p>P4 Lab tutorials.</p> <p>P5 Use of study materials (e-version of lecture materials).</p> <p>P15 Use of video contents as preparation for lectures and tutorials.</p>
---	---

Načini ocenjevanja:

Delež/Weight

Assessment:

Teoretična snov (predavanja)	50,00 %	Theoretical knowledge (lecture)
Samostojno delo na vajah	20,00 %	Independent tutorial work
Laboratorijsko delo na vajah (vključno s poročili)	20,00 %	Lab tutorial work (with reports)
Seminar	10,00 %	Seminar

Reference nosilca/Lecturer's references:

Mitjan Kalin:

1. KITANO, Houichi, DOHDA, Kuniaki, KALIN, Mitjan, EHMANN, Kornel F. Gallium growth analysis in metal forming. *Manufacturing letters*. Apr. 2018, vol. 16, f. 32-35, ilustr. ISSN 2213-8463.
2. BRODNIK ŽUGELJ, Blaž, KALIN, Mitjan. Submicron-scale experimental analyses of multi-asperity contacts with different roughnesses. *Tribology international*. [Print ed.]. Mar. 2018, vol. 119, str. 667-671, ilustr. ISSN 0301-679X.
3. POLAJNAR, Marko, BIZJAN, Benjamin, ŠIROK, Brane, KALIN, Mitjan. High-speed optical imaging of liquid film flow and liquid macro-slip over free surfaces with different surface energies. *Lubrication science*. Online ed. Dec. 2017, vol. 29, iss. 8, f. 557-566, ilustr. ISSN 1557-6833.
4. BRODNIK ŽUGELJ, Blaž, KALIN, Mitjan. In-situ observations of a multi-asperity real contact area on a submicron scale. *Strojniški vestnik*. June 2017, vol. 63, no. 6, str. 351-362, si 51, ilustr. ISSN 0039-2480.
5. KALIN, Mitjan, POGAČNIK, Aljaž, ETSION, I., RAEYMAEKERS, B. Comparing surface topography parameters of rough surfaces obtained with spectral moments and deterministic methods. *Tribology international*. [Print ed.]. Jan. 2016, vol. 93, pt. a, str. 137-141, ilustr. ISSN 0301-679X.