

## UČNI NAČRT PREDMETA/COURSE SYLLABUS

<b>Predmet:</b>	Maziva in mazanje
<b>Course title:</b>	Lubricants and lubrication
<b>Članica nosilka/UL Member:</b>	UL FS

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

**Univerzitetna koda predmeta/University course code:** 0563424

**Koda učne enote na članici/UL Member course code:** 3043-V

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

**Nosilec predmeta/Lecturer:** Mitjan Kalin

**Vrsta predmeta/Course type:** Izbirni strokovni predmet/Elective specialised course

<b>Jeziki/Languages:</b>	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):**

<ol style="list-style-type: none"> <li>Predavanje: Uvod: <ul style="list-style-type: none"> <li>Pomen, zgodovina, vzdrževanje, ekonomski vpliv.</li> </ul> </li> <li>Predavanje: Tribološki kontakti in sistem: <ul style="list-style-type: none"> <li>Značilnosti inženirskih materialov, površin, razlike z osnovnimi materiali, maziva in njihova vloga v kontaktu, obrabni delci in njihova vloga v kontaktu.</li> <li>Tribološki sistem.</li> </ul> </li> <li>Predavanje: Bazna olja: <ul style="list-style-type: none"> <li>Surova nafta, proizvodnja olj, sestava olj, mineralna, sintetična in biološko razgradljiva.</li> </ul> </li> <li>Predavanje: Aditivi za izboljšanje triboloških</li> </ol>	<ol style="list-style-type: none"> <li>Lecture: Introduction: <ul style="list-style-type: none"> <li>Importance, history, maintenance, economic impact.</li> </ul> </li> <li>Lecture: Tribological contacts and system: <ul style="list-style-type: none"> <li>Characteristics of engineering materials, surfaces, differences with basic materials, lubricants and their role in contact, wear particles and their role in contact.</li> <li>Tribological system.</li> </ul> </li> <li>Lecture: Base oils: <ul style="list-style-type: none"> <li>Crude oil, oil production, oil composition, synthetic and biodegradable.</li> </ul> </li> </ol>
--	--

<p>lastnosti:</p> <ul style="list-style-type: none"> <li>- Modifikatorji trenja, protiobrabni aditivi, aditivi za ekstremne pogoje: lastnosti, formulacija, vplivi.</li> </ul> <p>5. Predavanje: Aditivi za vzdrževanja stanja olja:</p> <ul style="list-style-type: none"> <li>- Protioksidacijski, protikorozijski, protipelnilni, detergenti in disperzanti,</li> <li>- Aditivi za viskoznost: lastnosti, formulacija, vplivi.</li> </ul> <p>6. Predavanje: Fizikalno kemijske lastnosti maziv:</p> <ul style="list-style-type: none"> <li>- Kinematična in dinamična viskoznost, odvisnosti od tlaka, temperaturne lastnosti, kontaminacija, nečistoče, vpliv vode.</li> </ul> <p>7. Predavanje: Režimi mazanja s popolnim filmom:</p> <ul style="list-style-type: none"> <li>- Hidrodinamično mazanje, elastohidrodinamično mazanje, enačbe, primeri, izračuni.</li> </ul> <p>8. Predavanje: Mešano in mejno mazanje:</p> <ul style="list-style-type: none"> <li>- Značilnosti, prehod, lambda koeficient, pomen, kontaktne razmere in povezani mehanizmi mazanja, primeri.</li> </ul> <p>9. Predavanje: Maziva za manj zahtevne pogoje:</p> <ul style="list-style-type: none"> <li>- turbinska olja, kompresorska olja, hidravlična olja, olja za zobnike.</li> </ul> <p>10. Predavanje: Maziva za zahtevne pogoje:</p> <ul style="list-style-type: none"> <li>- Olja za motorje z notranjim zgorevanjem, olja za preoblikovanje, olja za odrezavanje, emulzije.</li> </ul> <p>11. Predavanje: Masti:</p> <ul style="list-style-type: none"> <li>- Značilnosti, fizikalno-kemijske lastnosti, mehanske lastnosti, posebnosti, primeri, uporaba.</li> </ul> <p>12. Predavanje: Okoljski in zdravstveni vidiki maziv:</p> <ul style="list-style-type: none"> <li>- Zakonodaja, trendi, spremembe, zbiranje olj, emulzije, varnostni vidik, zdravje.</li> </ul> <p>13. Predavanje: Diagnostika maziv:</p> <ul style="list-style-type: none"> <li>- Spremljanje stanja parametrov maziv, degradacija, odpovedi maziv, parametri spremljanja, postopki, meritve.</li> </ul> <p>14. Predavanje: Preizkušanje triboloških lastnosti maziv:</p> <ul style="list-style-type: none"> <li>- Metode, naprave, parametri za analizo, standardi, modelni testi, realni testi.</li> </ul> <p>15. Predavanje: Primeri in uporaba maziv (Viharjenje):</p> <ul style="list-style-type: none"> <li>- Refleksija vsebin: povezovanje zahtev uporabe, funkcije maziv, potrebnih lastnosti maziv, način izbora maziva in validacija.</li> </ul>	<p>4. Lecture: Additives to improve tribological properties:</p> <ul style="list-style-type: none"> <li>- Friction modifiers, anti-wear additives, additives for extreme conditions: properties, formulation, effects.</li> </ul> <p>5. Lecture: Oil maintenance additives:</p> <ul style="list-style-type: none"> <li>- Antioxidant, anti-corrosion, anti-foaming, detergents and dispersants,</li> <li>- Viscosity additives: properties, formulation, effects.</li> </ul> <p>6. Lecture: Physical and chemical properties of lubricants:</p> <ul style="list-style-type: none"> <li>- Kinematic and dynamic viscosity, pressure dependencies, temperature characteristics, contamination, impurities, water influence.</li> </ul> <p>7. Lecture: Full film lubrication modes:</p> <ul style="list-style-type: none"> <li>- Hydrodynamic lubrication, elastohydrodynamic lubrication, equations, examples, calculations.</li> </ul> <p>8. Lecture: Mixed and boundary lubrication:</p> <ul style="list-style-type: none"> <li>- Characteristics, transition, lambda coefficient, importance, contact conditions and associated lubrication mechanisms, examples.</li> </ul> <p>9. Lecture: Lubricants for less demanding conditions:</p> <ul style="list-style-type: none"> <li>- turbine, compressor, hydraulic, gear oils.</li> </ul> <p>10. Lecture: Lubricants for demanding conditions:</p> <ul style="list-style-type: none"> <li>- Oils for internal combustion engines, oils for stamping, cutting oils, emulsions.</li> </ul> <p>11. Lecture: Greases:</p> <ul style="list-style-type: none"> <li>- Characteristics, physicochemical properties, mechanical properties, special features, examples, applications.</li> </ul> <p>12. Lecture: Environmental and health aspects of lubricants:</p> <ul style="list-style-type: none"> <li>- Legislation, trends, changes, oil, health collection, emulsions, safety aspect.</li> </ul> <p>13. Lecture: Lubricant diagnostics:</p> <ul style="list-style-type: none"> <li>- Monitoring of lubricant parameters, degradation, lubricant failure, monitoring parameters, procedures, measurements.</li> </ul> <p>14. Lecture: Testing of tribological properties of lubricants:</p> <ul style="list-style-type: none"> <li>- Methods, devices, parameters for analysis, standards, model tests, real tests.</li> </ul> <p>15. Lecture: Examples and use of lubricants (Brainstorming):</p> <ul style="list-style-type: none"> <li>- Content reflection: linking application requirements, lubricant features, required lubricant properties, lubricant selection method and validation.</li> </ul>
---	--

#### Temeljna literatura in viri/Readings:

1. Gwidon W. Stachowiak, Andrew W. Batchelor, Engineering tribology, Elsevier, 4th edition, 2014, ISBN 978-0-12-397047-3.
2. T. Mang, W. Dresel, J. Wiley, Lubricants and lubrication. Weinheim, Germany: Wiley-Vch, 2007, ISBN: 978-3-527-61033-4.

### Cilji in kompetence:

#### Cilji:

1. Spoznati in razumeti pomen mazanja in maziv
2. Spoznati in razumeti lastnosti maziv in aditivov, ter interakcije med površino in mazivom
3. Razumeti okoljske in zdravstvene vidike maziv
4. Znati izmeriti, analizirati in vrednotiti določene torne razmere v različnih aplikacijah

#### Kompetence:

1. P1-PAP: Poznavanje splošnih teoretičnih znanj na področju maziv in mazanja.
2. S1-PAP, P8-PAP: Sposobnost izbire ustreznih maziv in metode mazanja glede na zahteve.
3. S9-PAP, P6-PAP: Poznavanje okoljskih zahtev in omejitev za maziva in additive.

S13-PAP, P4-PAP: Sposobnost analize, vrednotenja in kritične presoje tornih razmer v različnih aplikacijah.

### Objectives and competences:

#### Objectives:

1. To know and understand the importance of lubrication and lubricants
2. To know and understand the properties of lubricants and additives, and the interactions between the surface and the lubricant
3. Understand the environmental and health aspects of lubricants
4. Be able to measure, analyze and evaluate specific friction conditions in applications

#### Competences:

1. P1-PAP: Expertise of general theoretical knowledge of lubricants and lubricants.
2. S1-PAP, P8-PAP: Ability to choose suitable lubricants and lubrication methods according to requirements.
3. S9-PAP, P6-PAP: Knowledge of environmental requirements and restrictions for lubricants and additives.

S13-PAP, P4-PAP: Ability to analyze, evaluate and critically evaluate friction conditions in various applications.

### Predvideni študijski rezultati:

#### Znanja:

Poglobljeno strokovno teoretično in praktično znanje na področju maziv in mazanja, podprto s širšo teoretično in metodološko osnovo o mazanju.

#### Spretnosti:

1. S1 Sposobnost načrtovanja mazanih kontaktov z ustrezno izbiro maziv in načinov mazanja.
2. S1.2 Samostojna uporaba pridobljenega znanja pri analizi in snovanju mazanih kontaktov.
3. S1.3 Sposobnost izbire maziv z okolju prijaznejšimi mazivi in mehanizmi mazanja.

S1.4 Sposobnost nadaljnjega, samostojnega študija.

### Intended learning outcomes:

#### Knowledge:

In-depth professional theoretical and practical knowledge in the field of lubricants and lubrication, supported by a broader theoretical and methodological basis for lubrication.

#### Skills:

1. S1 Ability to design lubricated contacts with appropriate selection of lubricants and lubrication methods.
2. S1.2 Independent use of acquired knowledge in the analysis and design of lubricated contacts.
3. S1.3 Ability to choose lubricants with greener lubricants and lubrication mechanisms.

S1.4 Ability to study further independently.

### Metode poučevanja in učenja:

P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.

### Learning and teaching methods:

P1 Auditorial lectures by solving selected - for the area of typical - theoretical and practical examples.

P2 Discussion of the subject matter according to an

P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki.	orderly and pre-explained systematics.
P3 Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri.	P3 Auditorial tutorials where theoretical knowledge from lectures is supported by computational examples
P4 Laboratorijske vaje.	P4 Laboratory tutorials.
P5 Uporaba študijskega gradiva v obliki (e-verzija predstavitev predavanj).	P5 Use of study materials in format (e-version of lecture presentation).
P15 Uporaba video vsebin kot priprava na predavanja in vaje	P15 Using video content to prepare for lectures and tutorials

#### Načini ocenjevanja:

#### Delež/Weight

#### Assessment:

Teoretična snov (predavanja).	50,00 %	Theoretical subject matter (lectures). Independent work in tutorials. Laboratory work in tutorials (including reports). Seminar.
Samostojno delo na vajah.	20,00 %	Independent work in tutorials.
Seminar.	10,00 %	Seminar.

#### Reference nosilca/Lecturer's references:

Mitjan Kalin:

1. TOMALA, Agnieszka, RODRÍGUEZ RIPOLL, Manel, KOGOVŠEK, Janez, **KALIN, Mitjan**, BEDNARSKA, A., MICHALCZEWSKI, R., SZCZEREK, M. Synergisms and antagonisms between MoS [sub] 2 nanotubes and representative oil additives under various contact conditions. *Tribology international*. [Print ed.]. Jan. 2019, vol. 129, str. 137-150, ilustr. ISSN 0301-679X.]
2. AKBARI, Somayeh, KOVAČ, Janez, **KALIN, Mitjan**. Effect of ZDDP concentration on the thermal film formation on steel, hydrogenated non-doped and Si-doped DLC. *Applied Surface Science*. [Print ed.]. Oct. 2016, vol. 383, str. 191-199, ilustr. ISSN 0169-433
3. **KALIN, Mitjan**. Designing tribological interface for efficient and green DLC lubrication : the role of coatings and lubricants : [plenary lecture]. V: *Lubricant additive technology for green innovation : symposium : preprints*. Hiroshima: Japanese Society of Tribologists, 2011. Str. 2-9. [COBISS.SI-ID [12109851](#)]
4. **KALIN, Mitjan**, OBLAK, Eva, AKBARI, Somayeh. Evolution of the nano-scale mechanical properties of tribofilms formed from low- and high-SAPS oils and ZDDP on DLC coatings and steel. *Tribology international*. [Print ed.]. Apr. 2016, vol. 96, str. 43-56, ilustr. ISSN 0301-679X. DOI:
5. PEJAKOVIĆ, Vladimir, TOMASTIK, C., DÖRR, Nora, **KALIN, Mitjan**. Influence of concentration and anion alkyl chain length on tribological properties of imidazolium sulfate ionic liquids as additives to glycerol in steel-steel contact lubrication. *Tribology international*. [Print ed.]. May 2016, vol. 97, str. 234-243, ilustr. ISSN 0301-679X.