

UČNI NAČRT PREDMETA/COURSE SYLLABUS

| | |
|-----------------------------------|--------------------------|
| Predmet: | Strojni elementi 1 - RRP |
| Course title: | MACHINE ELEMENTS 1 - RRP |
| Članica nosilka/UL Member: | UL FS |

| Študijski programi in stopnja | Študijska smer | Letnik | Semestri |
|--|---------------------------------|-----------|-------------|
| Strojništvo - razvojno raziskovalni program, prva stopnja, univerzitetni | Ni členitve (študijski program) | 2. letnik | 1. semester |

Univerzitetna koda predmeta/University course code: 0562753

Koda učne enote na članici/UL Member course code: 2016-U

| Predavanja | Seminar | Vaje | Klinične vaje | Druge oblike študija | Samostojno delo | ECTS |
|------------|---------|------|---------------|----------------------|-----------------|------|
| 45 | | 30 | | | 50 | 5 |

Nosilec predmeta/Lecturer: Jernej Klemenc, Marko Nagode

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 Univerzitetni študijski program I. stopnje Strojništvo - Razvojno raziskovalni program.

Meeting the enrollment conditions for the Academic study programme of Mechanical Engineering - Research and Development program.

Vsebina:

Content (Syllabus outline):

Predavanja: Uvod v strojne elemente in statične materialne lastnosti:

- Izdelek v povezavi s pogoji uporabe, okolja in vzdrževanja, obremenitvami, zdržljivostjo, funkcionalnostjo in vrstami okvar.
- Statične materialne lastnosti.

2. Predavanja: Vrste obremenitev in dinamične materialne lastnosti:

- Wöhlerjeva krivulja z raztrosi.
- Poškodbeni kriteriji.
- Akumulacija utrujenostnih poškodb.

Lecture: Introduction to machine elements and static material properties:

- Product in correlation with usage, environmental and maintenance conditions, loading, endurance, functionality and types of failures.
- Static material properties.

2. Lecture: Types of loads and dynamic material properties:

- Wöhler curve and its scatter.
- Damage criteria.
- Fatigue damage accumulation.

| | |
|---|--|
| <p>3. Predavanje: Dinamične materialne lastnosti:</p> <ul style="list-style-type: none"> - Trajna dinamična trdnost. - Oblikovna trdnost. - Zarezni učinek. - Podporni učinek. - Vpliv hrapavosti površine in velikosti prereza. <p>4. Predavanje: Zvarni spoji:</p> <ul style="list-style-type: none"> - Delitev in vrste zvarnih spojev. - Nastanek in odpravljanje zaostalih napetosti. <p>5. Predavanje: Zvarni spoji:</p> <ul style="list-style-type: none"> - Osnovni principi vrednotenja zvarnih spojev na statično nosilnost in utrujanje. - Oblikovanje zvarnih spojev. <p>6. Predavanje: Tlačne posode:</p> <ul style="list-style-type: none"> - Materialne lastnosti lezenja. - Osnovni principi vrednotenja tlačnih posod. - Oblikovanje tlačnih posod. <p>7. Predavanje: Lotni in zlepní spoji:</p> <ul style="list-style-type: none"> - Fizikalne osnove lotanja in lepljenja. - Osnovni principi vrednotenja lotnih in zlepnih spojev na statično nosilnost in utrujanje. - Oblikovanje lotnih in zlepnih spojev. <p>8. Predavanje. Vijačni spoji:</p> <ul style="list-style-type: none"> - Vrste vijačnih spojev. - Privijanje in odvijanje vijaka ter moment ključa. - Prednapeti vijačni spoji. - Oblikovanje prednapetih vijačnih spojev. <p>9. Predavanje. Vijačni spoji:</p> <ul style="list-style-type: none"> - Osnovni principi vrednotenja prednapetih vijačnih spojev na statično nosilnost in utrujanje. <p>10. Predavanje: Vzmeti:</p> <ul style="list-style-type: none"> - Osnovni principi vrednotenja kovinskih in nekovinskih vzmeti na statično nosilnost in utrujanje. <p>11. Predavanje: Vzmeti:</p> <ul style="list-style-type: none"> - Volumski izkoristek in oblikovanje vzmeti. <p>12. Predavanje: Kotalni ležaji:</p> <ul style="list-style-type: none"> - Fizikalne osnove kotalnih ležajev. - Vrste kotalnih ležajev. - Osnovni principi vrednotenja kotalnih ležajev na statično nosilnost in utrujanje. - Oblikovanje ležajnih mest. <p>13. Predavanje: Drsní ležaji:</p> <ul style="list-style-type: none"> - Fizikalne osnove drsnih ležajev. - Vrste drsnih ležajev. - Vrste trenja, hidrostatično in hidrodinamično mazanje. - Oblikovanje in vrednotenje drsnih ležajev. <p>14. Predavanje: Tesnila in prirobníčne zveze:</p> <ul style="list-style-type: none"> - Vrste tesnil. - Fizikalne osnove prirobníčnih zvez. - Izbira tesnil in oblikovanje prirobníčnih zvez. <p>15. Predavanje: Kovičeni spoji:</p> <ul style="list-style-type: none"> - Fizikalne osnove kovičenja. - Oblikovanje in vrednotenje kovičenih spojev. | <p>3. Lecture: Dynamic material properties:</p> <ul style="list-style-type: none"> - Endurance limit of test specimen. - Endurance limit of part. - Notch effect. - Support effect. - Surface roughness effect and size effect. <p>4. Lecture: Welded joints:</p> <ul style="list-style-type: none"> - Division and types of welded joints. - Origin and elimination of residual stresses. <p>5. Lecture: Welded joints:</p> <ul style="list-style-type: none"> - Basic principles of welded joint evaluation on static load and fatigue. - Design of welded joints. <p>6. Lecture: Pressure vessels:</p> <ul style="list-style-type: none"> - Creep material properties. - Basic principles of pressure vessel evaluation. - Design of pressure vessels. <p>7. Lecture: Soldered and bonded joints:</p> <ul style="list-style-type: none"> - Physical backgrounds of soldering and bonding. - Basic principle of soldered and bonded joint evaluation on static load and fatigue life. - Design of soldered and bonded joints. <p>8. Lecture. Bolts:</p> <ul style="list-style-type: none"> - Types of bolts. - Tightening and untightening of bolts and torque of the tightening tool. - Pretensioned bolts. - Design of pretensioned bolts. <p>9. Lecture. Bolts:</p> <ul style="list-style-type: none"> - Basic evaluation principles of pretensioned bolts on static load and fatigue. <p>10. Lecture: Springs:</p> <ul style="list-style-type: none"> - Basic principles of metal and non-metal spring evaluation on static load and fatigue life. <p>11. Lecture: Springs:</p> <ul style="list-style-type: none"> - Volumetric efficiency and design of springs. <p>12. Lecture: Roller bearings:</p> <ul style="list-style-type: none"> - Physical backgrounds of roller bearings. - Types of roller bearings. - Basic principles of roller bearings evaluation on static load and rating life. - Design of bearing supports. <p>13. Lecture: Sliding bearings:</p> <ul style="list-style-type: none"> - Physical backgrounds of sliding bearings. - Types of sliding bearings. - Types of friction, hydrodynamic and hydrostatic lubrication. - Design and evaluation of sliding bearings. <p>14. Lecture: Washers and flange connections:</p> <ul style="list-style-type: none"> - Types of washers. - Physical backgrounds of flange connections. - Washer selection and design of flange connections. <p>15. Lecture: Riveted joints:</p> <ul style="list-style-type: none"> - Physical backgrounds of riveting. |
|---|--|

- Design and evaluation of riveted joints.

Temeljna literatura in viri/Readings:

1. Wittel H., Jannasch D., Vossiek J., Spura C. Roloff/Matek Maschinenelemente - 23. Auflage. Springer Vieweg, 2017. Izbrana poglavja
2. Decker K.H. Decker Maschinenelemente - 20 Auflage. Carl Hanser Verlag, 2018. Izbrana poglavja
3. Ren Z., Glodež S. Strojni elementi I. del. Založništvo Fakultete za strojništvo, Maribor, 2003. Izbrana poglavja

Cilji in kompetence:

Cilji:

1. Spoznati fizikalne in matematične osnove izbranih strojnih elementov.
2. Spoznati osnovne principe vrednotenja izbranih strojnih elementov na statično nosilnost, utrujanje in lezenje.
3. Spoznati dobre in slabe prakse oblikovanja izbranih strojnih elementov.
4. Spoznati programska orodja za oblikovanje in vrednotenje strojnih elementov in komponent.
5. Spoznati osnovne principe povezovanja strojnih elementov v komponente in izdelke.

Kompetence:

1. S2-RRP: Sposobnost kritičnega, analitičnega in sintetičnega razumevanja strojnih elementov.
2. S5-RRP: Sposobnost uporabe informacijsko-komunikacijske tehnologije.
3. S6-RRP: Usposobljenost za uporabo pridobljenih znanj pri samostojnem reševanju manj zahtevnih tehničnih problemov v strojništvu.
4. P4-RRP: Sposobnost osnovnega fizikalnega in matematičnega modeliranja strojnih elementov s sposobnostjo kritične analize rezultatov.
5. P6-RRP: Sposobnost samostojnega izvajanja manj zahtevnih razvojnih in inženirskih del ter sposobnost kreativnega reševanja dobro definiranih nalog na področju strojništva.

Objectives and competences:

Objectives:

1. Gain fundamental knowledge of selected machine elements pertaining to physics and mathematics.
2. Gain basic evaluation principles of selected machine elements pertaining to the static load-bearing ability, fatigue and wear.
3. Gain knowledge of good and bad design of selected machine elements.
4. Gain knowledge of computer software to design and evaluate machine elements and components.
5. Gain knowledge of fundamental principles to assemble machine elements into components and products.

Competences:

1. S2-RRP: Development of creative, analytical and synthetic thinking in the field of machine elements.
2. S5-RRP: The ability to use information and communication technology.
3. S6-RRP: The ability to use the acquired knowledge to solve professional engineering problems independently.
4. P4-RRP: The ability of basic physical, mathematical and numerical modelling of machine elements with the ability of critically analysing the results.
5. P6-RRP: A Level 1 graduate is able to perform easier development, engineering and professional organisational tasks as well as to solve individual well-defined engineering tasks.

Predvideni študijski rezultati:

Znanja:

Z1: Poglobljeno strokovno teoretično in praktično znanje na določenem področju, podprto s širšo teoretično in metodološko osnovo.

- Poglobljeno strokovno teoretično in praktično znanje s področij statičnih materialnih lastnosti, materialnih lastnosti utrujanja in lezenja, zvarnih, lotnih zlepnih in vijačnih spojev, tlačnih posod, vzmeti, kotalnih in drsnih

Intended learning outcomes:

Knowledge:

Z1: In-depth professional theoretical and practical knowledge of a certain field, supported by a broader theoretical and methodological fundament.

- In-depth professional theoretical and practical knowledge of static material properties, material properties of fatigue and creep, welded, soldered, glued and bolted joints, pressure vessels, springs, roller and

| | |
|---|---|
| ležajev, tesnil in prirobnicnih zvez. | fluid bearings, washers and flange connections. |
| Spretnosti: | Skills: |
| S1.1 Izvajanje kompleksnih operativno -strokovnih opravil, ki vključujejo tudi uporabo metodoloških orodij. | S1.1 Performance of complex operational-professional tasks which include the use of methodological tools. |
| - Izvajanje vrednotenj strojnih elementov skladno s sodobno literaturo in veljavnimi standardi. | - Evaluation of machine elements in accordance with contemporary literature and latest standards. |
| S1.2 Obvladovanje zahtevnih, kompleksnih delovnih procesov ob samostojni uporabi znanja v novih delovnih situacijah. | S1.2 Mastering of demanding, complex operational processes and autonomous use of knowledge in new professional circumstances. |
| - Obvladovanje analitičnih in preprostih numeričnih orodij za oblikovanje in vrednotenje strojnih elementov, komponent in izdelkov. | - Mastering analytical and simple numerical tools for design and evaluation of machine elements, components and products. |

Metode poučevanja in učenja:

Learning and teaching methods:

| | |
|--|--|
| P1: Avditorna predavanja z reševanjem izbranih teoretičnih in praktično uporabnih primerov. | P1: Auditory lectures including solution procedures for selected theoretical and practical examples. |
| P3: Avditorne vaje, kjer se teoretično znanje s predavanj podprepi z računskimi primeri. | P3: Auditory exercises where theoretical knowledge gained at auditory lectures is substantiated by numerical examples. |
| P4: Laboratorijske vaje, kjer se teoretično znanje s predavanj podprepi z laboratorijskimi preskusi. | P4: Laboratory exercises where theoretical knowledge gained at auditory lectures is substantiated by laboratory experiments. |
| P7+P15: Video predavanja in vaje z diskusijo. | P7+P15: Video lectures and exercises with discussion. |

Načini ocenjevanja:

Delež/Weight

Assessment:

| | | |
|--|---------|---|
| - Teoretične vsebine (predavanja). | 50,00 % | - Theoretical knowledge (lectures). |
| - Samostojno delo na vajah. | 20,00 % | - Individual work at exercises. |
| - Delo na laboratorijskih vajah (vključno s poročili). | 20,00 % | - Work at laboratory exercises (including reports). |
| - Seminar. | 10,00 % | - Seminar. |

Reference nosilca/Lecturer's references:

Marko Nagode:

- OKORN, Ivan, **NAGODE, Marko**, KLEMENC, Jernej. Analysis on damage to rolling bearings at small turning angles. Strojniški vestnik, ISSN 0039-2480, Apr. 2018, vol. 64, no. 4, str. 209-215, ilustr. <http://www.sv-jme.eu/article/analysis-on-damage-to-rolling-bearings-at-small-turning-angles/>, doi: 10.5545/sv-jme.2017.5063. [COBISS.SI-ID 16007707]Ref 2
- OMAN, Simon, **NAGODE, Marko**. Bolted connection of an end-plate cantilever beam : the distribution of operating force. Strojniški vestnik, ISSN 0039-2480, Nov. 2017, vol. 63, no. 11, str. 617-627, ilustr., doi: 10.5545/sv-jme.2017.4638. [COBISS.SI-ID 15744795]
- PEČNIK, Matija, **NAGODE, Marko**, ŠERUGA, Domen. Influence of geometry and safety factor on fatigue damage predictions of a cantilever beam. Structural engineering and mechanics, ISSN 1225-4568, Apr. 2019, vol. 70, no. 1, str. 33-41, ilustr. <http://www.techno-press.org/download.php?journal=sem&volume=70&num=1&ordernum=3>, doi: 10.12989/sem.2019.70.1.03 [COBISS.SI-ID 16558875]

4. ŠERUGA, Domen, **NAGODE, Marko**, KLEMENC, Jernej. Measurement of stress-strain response during cyclic tests. V: JARFORS, Anders E. W. (ur.). Processing and fabrication of advanced materials-XXVII : proceedings of a conference, The 27th International Conference on Processing and Fabrication of Advanced Materials (PFAM-XXVII), 27-29 May 2019, Jönköping, Sweden. Jönköping: University. 2019, str. 103-108, ilustr. [COBISS.SI-ID 16644379]
5. OMAN, Simon, GOSAR, Aleš, **NAGODE, Marko**. Measurements and findings for a material with hard matrix embedded with diamonds (3M grade 35) : research study. Ljubljana: Faculty of Mechanical Engineering, LASEM, 2019. 15 f., ilustr. [COBISS.SI-ID 16440859]

Jernej Klemenc:

1. OKORN, Ivan, NAGODE, Marko, **KLEMENC, Jernej**. Analysis on damage to rolling bearings at small turning angles. Strojniški vestnik, Apr. 2018, vol. 64, no. 4, str. 209-215, doi: 10.5545/sv-jme.2017.5063. [COBISS.SI-ID 16007707]
2. ŠERUGA, Domen, NAGODE, Marko, **KLEMENC, Jernej**. Eliminating friction between flat specimens and an antibuckling support during cyclic tests using a simple sensor. Measurement science & technology, 2019, vol. 30, no. 9, str. 1-15, doi: 10.1088/1361-6501/ab1e35. [COBISS.SI-ID 16600091]
3. BIŽAL, Ana, **KLEMENC, Jernej**, FAJDIGA, Matija. Estimating a PDF of parameters of oxide inclusions on fatigue fracture surface of standardized specimen. Tehnički vjesnik : znanstveno-stručni časopis tehničkih fakulteta Sveučilišta u Osijeku, 2013, vol. 20, no. 6, str. 985-993, http://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=16574 [COBISS.SI-ID 13279259]
4. ŠERUGA, Domen, NAGODE, Marko, **KLEMENC, Jernej**. Measurement of stress-strain response during cyclic tests. V: JARFORS, Anders E. W. (ur.). Processing and fabrication of advanced materials-XXVII : proceedings of a conference, The 27th International Conference on Processing and Fabrication of Advanced Materials (PFAM-XXVII), 27-29 May 2019, Jönköping, Sweden. Jönköping: University. 2019, str. 103-108, ilustr. [COBISS.SI-ID 16644379]
5. OMAN, Simon, NAGODE, Marko, **KLEMENC, Jernej**. Koncipiranje in vrednotenje novih načinov pritrjevanja solarnih panelov na ALU profile. Ljubljana: Faculty of mechanical engineering, Laboratory LASEM, sep. 2018. 14 f., ilustr. [COBISS.SI-ID 16211739]