# RAZVOJNI IN VZDRŽEVALNI POSTOPKI V LETALSTVU

# UČNI NAČRT PREDMETA/COURSE SYLLABUS

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| **Predmet:** | Razvojni in vzdrževalni postopki v letalstvu |
| **Course title:** | Development and Maintenance Processes in Aueronautics |
| **Članica nosilka/UL Member:** | UL FS |

| Študijski programi in stopnja | Študijska smer | Letnik | Semestri | Izbirnost |
|---|---|---|---|---|
| Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni | Ni členitve (študijski program) | 3. letnik | 2. semester | izbirni |

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| **Univerzitetna koda predmeta/University course code:** | 0564088 |
| **Koda učne enote na članici/UL Member course code:** | 3097-V |

| Predavanja /Lectures | Seminar /Seminar | Vaje /Tutorials | Klinične vaje /Clinical tutorials | Druge oblike študija /Other forms of study | Samostojno delo /Individual student work | ECTS |
|---|---|---|---|---|---|---|
| 30 | | 30 | | | 90 | 6 |

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| **Nosilec predmeta/Lecturer:** | izr. prof. dr. Franc Majdič, izr. prof. dr. Miha Brojan, prof. dr. Mitjan Kalin, prof. dr. Roman Šturm, prof. dr. Tomaž Katrašnik, viš. pred. dr. Igor Petrović |

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| **Izvajalci predavanj:** | |
| **Izvajalci seminarjev:** | |
| **Izvajalci vaj:** | |
| **Izvajalci kliničnih vaj:** | |
| **Izvajalci drugih oblik:** | |
| **Izvajalci praktičnega usposabljanja:** | |

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

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

| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | **Prerequisites:** |
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| V sklopu predmeta se študent spozna s širšim področjem določenega dela tematike, ki jo bo obdelal v diplomski nalogi. Zato so pogoj za vključitev v delo opravljene študijske obveznosti prvih štirih semestrov študijskega programa PAP. | As part of the course, the student gets introduced to the broader field of a certain part of the topic, which he will deal with in the Bachelor's degree thesis. Therefore, the requirement for the course is completed study obligations of the first four semesters of the PAP study program. |

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

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| Glede na širši vidik obravnavane strokovne tematike diplomskega dela na področju snovanja in vzdrževanja letal študent izbere enega nosilca tega predmeta, ki prevzame vlogo mentorja. Predmet se izvaja pri treh izvajalcih, pri čemer sta študentu poleg mentorja dodeljena še dva soizvajalca iz širšega sorodnega strokovnega področja.<br>1. Predstavitev ciljev predmeta in posameznih razvojnih tematik, ki jih bodo študentje opravljali tekom leta.<br>2. Pregled strokovne literature dogovoru z izbranimi nosilci predmeta.<br>3. Interaktivna predstavitev obdelanih temeljnih vsebin z individualno ali skupinsko diskusijo.<br>4. Opredelitev individualnega parcialnega problema na obravnavanem področju ob vodenju nosilcev predmeta.<br>5. Priprava načrta iskanja rešitev za opredeljeni parcialni problem ob vodenju nosilcev predmeta.<br>6. Pregled in študij teoretičnih osnov izbrane tematike.<br>7. Študij gradnikov in procesov uporabnih v izbrani razvojni tematiki.<br>8. Tehnike snovanja in vrednotenja na področju izbrane razvojne tematike. Glede na tematiko bo večji podarek na nealitičnih oziroma numeričnih metodah modeliranja sistemov/procesov izbrane tematike.<br>9. Interaktivna predstavitev povzetka obdelanih specializiranih vsebin z individualno ali skupinsko diskusijo.<br>10. Zasnova in razvoj naprave / eksperimentalnega sistema / računskega modela v sklopu izbrane tematike.<br>11. Razvoj metodologije vrednotenja razvite naprave / eksperimentalnega sistema / računskega modela.<br>12. Razvoj in izvedba eksperimentalnega dela.<br>13. Primerjava rezultatov z napovedmi iz dostopne literature.<br>14. Interaktivna predstavitev eksperimentalnih, računalniških ali analitičnih orodij ter primerjava z ugotovitvami iz dostopne literature.<br>15. Pregled izzivov za prihodnost na področju izbrane razvojne tematike. | According to the broader aspect of the topic of the degree's thesis from the field of development and maintenance in aeronautics, the student chooses one lecturer of this course, who assumes the role of supervisor. The course is delivered by three lecturers; in addition to the supervisor, the student is assigned two additional lecturers from related fields of expertise.<br>1. Presentation of the course objectives and individual research topics that students will undertake throughout the year.<br>2. Review of the scientific literature in agreement with the chosen lecturers.<br>3. An interactive presentation of discussed core content through individual or group discussion.<br>4. Definition of an individual partial problem in the area under consideration guided by lecturers.<br>5. Preparation of a plan for finding solutions to the defined partial problem guided by lecturers.<br>6. Review and study of the theoretical basis of the selected topic.<br>7. Studies of the building blocks and processes applicable in the chosen topic.<br>8. Design and evaluation techniques in the field of the chosen topic. Depending on the topic, more emphasis will be given to the non-analytical, numerical methods of modelling systems / processes of the selected topic.<br>9. An interactive presentation of a summary of studied specialized content with individual or group discussion.<br>10. Design and development of the device / experimental system / computational model within the chosen topic.<br>11. Development of evaluation methodology of developed device / experimental system / computational model.<br>12. Development and implementation of experimental work.<br>13. Comparison of results and predictions from available literature.<br>14. Interactive presentation of experimental, computer or analytical tools and comparison with findings from available literature.<br>15. An overview of the challenges ahead for the chosen research topic. |

**Temeljna literatura in viri/Readings:**

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| Določena je smiselno v dogovoru z izbranim nosilcem predmeta za vsakega študenta posebej glede na izbrano problematiko. Literatura je dosegljiva v knjižnici laboratorija, fakultetni knjižnici ali širše. Praviloma študent študira iz člankov, ki so obravnavali podoben primer, kakor ga ima sam definiranega.<br>It is determined appropriately in agreement with the selected lecturer for each student according to the chosen topic. Literature is available at the lab library, faculty library or beyond. As a rule, a student studies from articles dealing with a similar case as he or she has defined. |

| **Cilji in kompetence:** | **Objectives and competences:** |
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| **Cilji:** | **Objectives:** |

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| 1. Omogočiti študentu seznanitev s temeljno in predmetno specifično literature na delu tematike, ki bo obravnavana v diplomski nalogi.<br>2. Seznanitev z namensko opremo na področju eksperimentiranja in uporabe računalniških orodij. Študent tako spozna osnovno funkcionalnost opreme, ki jo lahko uporabi.<br>3. Predmet se izvaja v laboratoriju (enem ali več) odvisno od dogovora z mentorjem in nosilci predmeta.<br>**Kompetence:**<br>S1-PAP: Sposobnost uporabe pridobljenega znanja v praksi.<br>S2-PAP: Sposobnost samostojnega dela v okviru znanj izbrane študijske smeri.<br>S4-PAP: Sposobnost razčlenitve lažjih strokovnih nalog na podnaloge.<br>S5-PAP: Razvijanje sposobnosti kritičnega in samokritičnega mišljenja.<br>S11-PAP: Sposobnost predstavitve strokovnih problemov in njihovih rešitev v svojem okolju in širše.<br>S13-PAP: Sposobnost iskanja virov znanja, selekcija najdenih virov in uporaba tako pridobljenega znanja pri svojem delu.<br>P4-PAP: Pozna osnovne merilne instrumente in merilne verige za merjenje osnovnih veličin na področju strojništva.<br>P6-PAP: Obvlada samostojno projektno delo.<br>P9-PAP: Diplomant je sposoben samostojno opravljati razvojno aplikativna, inženirska in strokovna organizacijska dela ter reševati posamezne dobro definirane naloge na področju strojništva. | 1. To enable the student to get acquainted with the basic and specific literature on the topic that will be discussed in the Bachelor's degree thesis.<br>2. To familiarize with the specific equipment in the field of experimentation and use of computer tools. Thus the student learns about the basic functionality of the equipment he can use.<br>3. The course is carried out in the laboratory (one or more), depending on the agreement with the mentor and course lecturers.<br>**Competencies:**<br>S1-PAP: The ability to use the attained knowledge in the practice.<br>S2-PAP: The ability to work autonomously in the framework of knowledge provided by the selected study module.<br>S4-PAP: The ability to break down professional tasks of lesser complexity into subtasks.<br>S5-PAP: Developing the ability of critical and self-critical thinking.<br>S11-PAP: The ability to present professional problems and the solutions thereof in own environment and wider.<br>S13-PAP: The ability to find sources of knowledge, select among the available resources and use the knowledge acquired for one's work.<br>P4-PAP: Knowing the basic measuring instruments and measuring chains used to measure the basic quantities in the field of mechanical engineering.<br>P6-PAP: Mastering independent project work.<br>P9-PAP: The graduates are able to independently perform applied developmental, engineering and professional organisational work, and to solve well-defined individual tasks in the field of mechanical engineering. |

| **Predvideni študijski rezultati:** | **Intended learning outcomes:** |
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| Znanja:<br>Z1: Poglobljeno strokovno teoretično in praktično znanje na določenem področju, podprto s širšo teoretično in metodološko osnovo.<br>Spretnosti:<br>S1.1 Izvajanje kompleksnih operativno-strokovnih opravil, ki vključujejo tudi uporabo metodoloških orodij.<br>S1.2 Obvladovanje zahtevnih, kompleksnih delovnih procesov ob samostojni uporabi znanja v novih delovnih situacijah.<br>S1.3 Diagnosticiranje in reševanje problemov v različnih specifičnih delovnih okoljih, povezanih s področjem izobraževanja in usposabljanja.<br>S1.4 Osnova za izvirna dognanja/ stvaritve in kritično refleksijo. | Knowledge:<br>Z1: Thorough professional theoretical and practical knowledge in a selected field of expertise that is supported with a broad theoretical and methodological basis.<br>Skills:<br>S1.1 Executing complex operational-professional tasks that incorporate usage of methodological tools.<br>S1.2 Mastering demanding and complex work processes by independent usage of knowledge in new working situations.<br>S1.3 Problem diagnostics and solving in different and specific working environments that are linked to the teaching and training content.<br>S1.4 Basis for unique innovations and critical reflections. |

| **Metode poučevanja in učenja:** | **Learning and teaching methods:** |
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| **Klasične oblike poučevanja:** | **Conventional teaching methods:** |

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| P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.<br>P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki.<br>P5 Uporaba študijskega gradiva v obliki skript, knjig, zapiskov, strokovnih člankov in predstavitev predavanj.<br>**Moderne in prožne oblike poučevanja:**<br>P6 Interaktivna predavanja<br>P7 Študij literature in razprava<br>P8 Izdelava in predstavitev aplikativnih seminarskih nalog<br>P14 Virtualni eksperimenti | P1 Auditorial lectures with solving selected field-specific theoretical and applied use cases.<br>P2 Presenting the content according to the explained system.<br>P5 Application of study material in form of scripts, textbooks, notes, professional artcles and printed lecture presentations.<br>**Contemporary and flexible teaching methods:**<br>P6 Interactive lectures.<br>P7 Literature study and discussion.<br>P8 Making and presenting applied seminar exercises.<br>P14 Virtual experiments. |

| **Načini ocenjevanja:** | **Delež/Weight** | **Assessment:** |
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| Ocena predstavitve končnih rezultatov. | 50,00 % | Presentation of final results. |
| Ocena končnega poročila. | 50,00 % | Evaluation of final report. |

| **Ocenjevalna lestvica:** | **Grading system:** |
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| 5 - 10, pri čemer velja, da je pozitivna ocena od 6 - 10 | 5 - 10, a student passes the exam if he is graded from 6 to 10 |

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

**Brojan Miha**

1. VELDIN, Tomo, BRANK, Boštjan, **BROJAN, Miha**. Computational finite element model for surface wrinkling of shells on soft substrates. *Communications in Nonlinear Science & Numerical Simulation*, ISSN 1007-5704, maj 2019, letn. XX, str. 1-29, ilustr. DOI: 10.1016/j.cnsns.2019.104863. [COBISS.SI-ID 8813409]
2. **BROJAN, Miha**, TERWAGNE, Denis, LAGRANGE, Romain, REIS, Pedro. Wrinkling crystallography on spherical surfaces. *Proceedings of the National Academy of Sciences of the United States of America*, ISSN 0027-8424, Jan. 2015, vol. 112, no. 1, str. 14-19, ilustr., DOI: 10.1073/pnas.1411559112. [COBISS.SI-ID 13852187].
3. TERWAGNE, Denis, **BROJAN, Miha**, REIS, Pedro. Smart morphable surfaces for aerodynamic drag control. Advanced materials, ISSN 0935-9648, Oct. 2014, vol. 26, iss. 38, str. 6608-6611, ilustr., DOI: 10.1002/adma.20140140 [COBISS.SI-ID 13725211]

**Kalin Mitjan**

1. **KALIN, Mitjan**, KUPEC, Alja. The dominant effect of temperature on the fatigue behaviour of polymer gears. *Wear*, ISSN 0043-1648. [Print ed.], Apr. 2017, vol. 376/377, part B, str. 1339-1346, ilustr. https://www.sciencedirect.com/science/article/pii/S0043164817302788?via%3Dihub, doi: 10.1016/j.wear.2017.02.003. [COBISS.SI-ID 15897115]
2. BARTOLOMÉ, Luis, OBLAK, Eva, **KALIN, Mitjan**. Mechanical behaviour and constitutive models of ZDDP tribofilms on DLC coatings using nano-indentation data and finite element modelling. *Tribology international*, ISSN 0301-679X, Mar. 2016, vol. 95, str. 19-26, ilustr. https://www.sciencedirect.com/science/article/pii/S0301679X15004958?via%3Dihub, doi: 10.1016/j.triboint.2015.10.036. [COBISS.SI-ID 14342939]
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**Katrašnik Tomaž**

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3. KREGAR, Ambrož, TAVČAR, Gregor, KRAVOS, Andraž, **KATRAŠNIK, Tomaž**. Predictive system-level modeling framework for transient operation and cathode platinum degradation of high temperature proton exchange membrane fuel cells. Applied energy, ISSN 0306-2619, 2020, vol. 263, 17 f. [COBISS.SI-ID 17037083]

**Majdič Franc**

1. STRMČNIK, Ervin, **MAJDIČ, Franc**, KALIN, Mitjan. Influence of a diamond-like carbon-coated mechanical part on the operation of an orbital hydraulic motor in water. *Metals*. Apr. 2019, vol. 9, iss. 4, f. 1-14, ilustr. ISSN 2075-470 https://www.mdpi.com/2075-4701/9/4/466, DOI: 10.3390/met9040466. [COBISS.SI-ID 16590107]
2. KALIN, Mitjan, POLAJNAR, Marko, KUS, Maja, **MAJDIČ, Franc**. Green tribology for the sustainable engineering of the future. *Strojniški vestnik*. Nov./Dec. 2019, vol. 65, no. 11/12, str. 709-727, ilustr. ISSN 0039-2480. https://www.sv-jme.eu/sl/article/green-tribology-for-sustainable-engineering-of-the-future/, DOI: 10.5545/sv-jme.2019.6406. [COBISS.SI-ID 16945179]
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**Šturm Roman**

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**Igor Petrović**

1. **PETROVIĆ, Igor**, ŠAJN, Viktor, KOSEL, Tadej, MARZOCCA, Pier. Aerodynamics and static aeroelastic behavior of low-Reynolds number deformable membrane wings. *Journal of aerospace engineering*. May 2016, vol. 29, iss. 3, str. 1-12, ilustr. ISSN 0893-1321. http://ascelibrary.org/doi/10.1061/%28ASCE%29AS.1943-5525.0000555, DOI: 10.1061/(ASCE)AS.1943-5525.0000555. [COBISS.SI-ID 14280475], [JCR, SNIP, WoS do 27. 7. 2022: št. citatov (TC): 4, čistih citatov (CI): 4, čistih citatov na avtorja (CIAu): 1,00, Scopus do 21. 7. 2022: št. citatov (TC): 4, čistih citatov (CI): 4, čistih citatov na avtorja (CIAu): 1,00] (1.01)
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