

ANALIZA IN SINTEZA MEHANIZMOV

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet: Analiza in sinteza mehanizmov

Course title: Mechanisms analysis and synthesis

Članica nosilka/UL Member: UL FS

Študijski programi in stopnja

Študijska smer

Letnik

Semestri

Izbirnost

Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni (od študijskega leta 2023/2024 dalje)

Konstruiranje strojev in naprav (smer)

3. letnik

1. semester

obvezni

Univerzitetna koda predmeta/University course code:

0563431

Koda učne enote na članici/UL Member course code:

3048-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

40

4

Nosilec predmeta/Lecturer:

Robert Kunc, Simon Krašna

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

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: Osnove
 - definicija mehanizmov
 - klasifikacija mehanizmov
 - funkcija mehanizmov
 - uporaba numeričnih simulacij pri analizi delovanja mehanizmov-1
2. Predavanje: Osnove - nadaljevanje
 - kinematične verige
 - prostostne stopnje
 - kinematične vezi
 - uporaba numeričnih simulacij pri analizi delovanja mehanizmov-2
3. Predavanje: Kinematika
 - prostostne stopnje 2D in 3D
 - shematski prikaz mehanizmov
 - primeri mehanizmov
4. Predavanja: Inverzije in mrtve lege
 - prostostne stopnje: neveljavnost Grüberjeve formule
 - kinematične inverzije
 - geometrijske inverzije
 - mrtve lege
5. Predavanje: Prenosna funkcija
 - funkcije mehanizmov
 - tvorjenje poti in gibanje togega telesa
 - kinematične prenosne funkcije
 - prenosno razmerje
6. Predavanje: Prenos gibanja in moči v mehanizmih

1. Lecture: Basics
 - Definition of mechanisms.
 - Classification of mechanisms.
 - Function of mechanisms.
 - Use of numerical simulations for analysis of the functioning of mechanisms - 1.
2. Lecture: Basics - continuation
 - Kinematic chains.
 - Degrees of freedom.
 - Kinematic joints.
 - Use of numerical simulations for analysis of the functioning of mechanisms - 2.
3. Lecture: Kinematics
 - Degrees of freedom 2D and 3D.
 - Schematic presentation of mechanisms.
 - Examples of mechanisms.
4. Lecture: Inversions and toggle positions
 - Degrees of freedom: Grüber formula - special cases
 - Kinematic inversions.
 - Geometric inversions.
 - Toggle positions.
5. Lecture: Transfer function
 - Functions of mechanisms.
 - Path formation and motion of a rigid

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| <ul style="list-style-type: none"> - prenosni kot - mrtve lege (nadaljevanje) - delovni in povratni gib <p>7. Predavanje: Kinematika – uvod v sintezo</p> <ul style="list-style-type: none"> - analiza lege in hitrosti - točka – lega - togo telo – lega in orientacija - kinematika 1D <p>8. Predavanje: 3D gibanje telesa-1</p> <ul style="list-style-type: none"> - 3D gibanje telesa - nepomični koordinatni system - pomični koordinatni system - transformacijska matrika - Eulerjevi koti - uporaba numeričnih simulacij pri analizi delovanja mehanizmov 1 <p>9. Predavanje: 3D gibanje telesa-2</p> <ul style="list-style-type: none"> - 3D gibanje telesa - nadaljevanje - hitrost izhodišča - relativna hitrost in pospešek - rotacija telesa - tangencialni, normalni in coriolisov pospešek <p>10. Predavanje: Kinematika – Poli hitrosti in pospeškov 1</p> <ul style="list-style-type: none"> - plan hitrosti - plan pospeškov - analiza kinematike s pomočjo planov hitrosti <p>11. Predavanje: Kinematika – Poli hitrosti in pospeškov 2</p> <ul style="list-style-type: none"> - poli hitrosti - poli pospeškov - poli hitrosti v tehniki vozil - analiza kinematike s pomočjo polov hitrosti - poloide <p>12. Predavanje: Krivuljni mehanizmi – Uvod</p> <ul style="list-style-type: none"> - krivuljni mehanizmi in njihove značilnosti - osnovni pojmi krivuljnih mehanizmov - izvedbe odmičnih krivulj in slednikov - osnovne zakonitosti gibanja in oblikovanja <p>13. Predavanje: Krivuljni mehanizmi – Analiza</p> <ul style="list-style-type: none"> - analiza krivuljnih mehanizmov - faze krivuljnih mehanizmov - SVAJ diagram | <p>body.</p> <ul style="list-style-type: none"> - Kinematic transfer functions. - Transfer ratio. <p>6. Lecture: Kinematic transfer function</p> <ul style="list-style-type: none"> - Transmission angle. - Toggle positions (continuation). - Forward and return stroke. <p>7. Lecture: Kinematics – Introduction into synthesis.</p> <ul style="list-style-type: none"> - Analysis of position and svelocity. - Point – position. - Rigid body – position and orientation. - Kinematics 1D. <p>8. Lecture: 3D body motion - 1</p> <ul style="list-style-type: none"> - 3D body motion. - Fixed reference frame. - Moving reference frame. - Transformation matrix. - Euler angles. - Use of numerical simulations for analysis of the functioning of mechanisms – 1. <p>9. Lecture: 3D body motion - 2</p> <ul style="list-style-type: none"> - 3D body motion – continuation. - Velocity of the local origin. - Relative velocity and acceleration. - Body rotation. - Tangential, normal and Coriolis acceleration. <p>10. Lecture: Kinematics – Instantaneous centre of velocity and acceleration 1</p> <ul style="list-style-type: none"> - Velocity polygon. - Acceleration polygon. - Analysis of kinematics by means of velocity polygons. <p>11. Lecture: Kinematics – Instantaneous centre of velocity and acceleration 2</p> <ul style="list-style-type: none"> - Instantaneous centre of velocity. - Instantaneous centre of acceleration. - Instantaneous centre of velocity in vehicle dynamics. - Analysis of kinematics by means of instantaneous centre of velocity. - Centrede. <p>12. Lecture: Cam followers – Introduction.</p> <ul style="list-style-type: none"> - Characteristics of cam followers. - Basic concepts of cam followers. - Design of cam curves and followers. |
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| <ul style="list-style-type: none"> - uporaba numeričnih simulacij pri analizi delovanja krivuljnih mehanizmov <p>14. Predavanje: Krivuljni mehanizmi – Sinteza</p> <ul style="list-style-type: none"> - sinteza krivuljnih mehanizmov - parabolične, cikloidne in harmonične oblike - določanje oblike odmičnih krivulj in slednikov - parabolične, cikloidne in harmonične oblike <p>15. Predavanje: Sinteza ročičnih mehanizmov</p> <ul style="list-style-type: none"> - proces konstruiranja - sinteza kinematike - grafična sinteza - uporaba numeričnih simulacij pri analizi in sintezi delovanja mehanizmov | <ul style="list-style-type: none"> - Basic principles of motion and design. <p>13. Lecture: Cam followers – Analysis</p> <ul style="list-style-type: none"> - Analysis of cam followers. - Phases of cam followers. - SVAJ diagram. - Use of numerical simulations for analysis of the functioning of cam followers. <p>14. Lecture: Cam followers – Synthesis</p> <ul style="list-style-type: none"> - Synthesis of cam followers. - Parabolic, cycloid and harmonic shapes. - Determining the shape of cam curves and followers. - Parabolic, cycloid and harmonic shapes. <p>15. Lecture: Synthesis of crank-slider mechanisms</p> <ul style="list-style-type: none"> - Design process. - Kinematic synthesis. - Graphic synthesis. - Use of numerical simulations for analysis of the functioning of mechanisms. |
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Temeljna literatura in viri/Readings:

Osnovna:

1. Uicker J. J., Pennock R. R., Shigley E. J.: Theory of Machines and Mechanisms, Third Edition, Oxford University Press, 2003.
2. Norton L. R.: Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, Second Edition, McGraw Hill, 2001.
3. Sclater N., Chironis N.: Mechanisms and Mechanical Devices Sourcebook, Third Edition, McGraw Hill Professional, 2001.

Dodatna:

4. Rothbart H.A.: Cam Design Handbook, McGraw-Hill, 2004.
5. Haug E.J.: Computer Aided Kinematics and Dynamics of Mechanical Systems, Allyn and Bacon, 1989.

Cilji in kompetence:

Cilji:

1. Spoznati osnovne pojme teorije mehanizmov, principe delovanja in izvedbe najbolj razširjenih tipov mehanizmov.
2. Pridobiti teoretično podlago za učinkovito analizo in sintezo

Objectives and competences:

Objectives:

1. Learning the basic terminology of the theory of mechanisms, principles of operation and designs of the most widely used types of mechanisms.
2. Understanding the theoretical basis for efficient analysis and synthesis of

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| <p>mehanizmov.</p> <p>3. Spoznati uporabo specializiranih programskih orodij.</p> <p>Kompetence:</p> <p>1. S4-PAP, P1-PAP: Sposobnost razčlenitve mehanizmov in naprav na posamezne funkcijske podsklope.</p> <p>2. P8-PAP: Sposobnost analize kinematike mehanizmov.</p> <p>3. S13-PAP, P9-PAP: Sposobnost snovanja osnovnih tipov mehanizmov.</p> | <p>mechanisms.</p> <p>3. Understanding the use of specialised software tools.</p> <p>Competences:</p> <p>1. S4-PAP, P1-PAP: Ability to break mechanisms and devices down into individual functional subassemblies.</p> <p>2. P8-PAP: Ability to perform analysis of the kinematics of mechanisms.</p> <p>3. S13-PAP, P9-PAP: Ability to design basic types of mechanisms.</p> |
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Predvideni študijski rezultati:

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| <p>Znanja:</p> <p>Z1: Poglobljeno strokovno teoretično in praktično znanje s področja analize in sinteze ročičnih in krivuljnih mehanizmov.</p> <p>Spretnosti:</p> <p>S1.1 Izvajanje kompleksnih operativno-strokovnih opravil, ki vključujejo tudi uporabo metodoloških orodij:</p> <ul style="list-style-type: none"> • Prepoznavanje in reševanje problemov s področja mehanizmov. • Obvladovanje analitičnih metod za analizo in sintezo enostavnih mehanizmov. <p>S1.2 Obvladovanje zahtevnih, kompleksnih delovnih procesov ob samostojni uporabi znanja v novih delovnih situacijah:</p> <ul style="list-style-type: none"> • Poznavanje računalniško podprtih tehnologij za analizo in sintezo mehanizmov. | <p>Knowledge:</p> <p>Z1: In-depth professional theoretical and practical knowledge in the field of analysis and synthesis of crank-slider mechanisms and cam followers.</p> <p>Skills:</p> <p>S1.1 Performance of complex operational and specialist tasks, including the use of methodological tools:</p> <ul style="list-style-type: none"> • Recognizing and solving problems in the field of mechanisms. • Understanding the use of analytical methods for analysis and synthesis of simple mechanisms. <p>S1.2 Understanding demanding and complex work processes based on independent use of knowledge in new work situations:</p> <ul style="list-style-type: none"> • Understanding computer-aided technologies for analysis and synthesis of mechanisms. |
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Metode poučevanja in učenja:

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| <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>P4 Laboratorijske vaje z namenski didaktičnimi pripomočki (različni mehanizmi v splošnem strojništvu in na področju vozil, namenski računalniški</p> | <p>P1 Auditory lectures with solving selected and typical theoretical and practical examples.</p> <p>P2 Presentation of subject matter based on the arranged and previously explained scheme.</p> <p>P4 Laboratory work with didactic tools (various mechanisms in general mechanical engineering and in the field of vehicles, computer software for</p> |
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Learning and teaching methods:

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| program za analizo in optimizacijo mehanizmov). | analysis and optimization of mechanisms). |
| P8 Izdelava in predstavitev aplikativnih seminarskih nalog. | P8 Creation and presentation of applicative seminar assignments. |
| P12 Individualizirane domače naloge v spletni učilnici. | P12 Individual homework assignments in a virtual classroom. |
| P14 Virtualni eksperimenti. | P14 Virtual experiments. |
| P15 Uporaba video vsebin kot priprava na predavanja in vaje. | P15 Use of video contents and preparation for lectures and tutorials. |

Načini ocenjevanja:

Delež/ Weight

Assessment:

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| Teoretični izpit (pisno/ustno). | 50,00 % | Theory examination (written/oral). |
| Delo na laboratorijskih vajah (vključno z izdelki). | 20,00 % | Practical examination in laboratory (written/oral). |
| Projektna naloga (pisno). | 30,00 % | Project work (written). |

Reference nosilca/Lecturer's references:

Robert Kunc:

1. **KUNC, Robert**, OMEROVIĆ, Senad, AMBROŽ, Miha, PREBIL, Ivan. Comparative study of european tunnel emergency-stop-area-wall protection measures. Accident analysis and prevention, ISSN 0001-4575, Feb. 2014, vol. 63, str. 9-21, ilustr., doi: 10.1016/j.aap.2013.10.020. [COBISS.SIID [13216027](#)]
2. ŽEROVNIK, Andrej, PEPEL, Vili, PREBIL, Ivan, **KUNC, Robert**. The yield-point phenomenon and cyclic plasticity of the uniaxially loaded specimens. Materials& design. Feb. 2016, vol. 92, str. 971-977, ilustr. ISSN 0264-1275P, DOI: 10.1016/j.matdes.2015.1111. [COBISS.SI-ID [14442011](#)]
3. PREBIL, Ivan, **KUNC, Robert**. Stahlleitplanken. V: BURG, Heinz (ur.), MOSER, Andreas (ur.). Handbuch Verkehrsunfallrekonstruktion : Unfallaufnahme, Fahrdynamik, Simulation, (Praxis), (ATZ-MTZ-Fachbuch). 2., aktualisierte Aufl. Wiesbaden: Vieweg + Teubner. 2009, str. 901-933, ilustr. [COBISS.SI-ID [11087387](#)]
4. **KUNC, Robert**, TRAJKOVSKI, Jovan, AMBROŽ, Miha, ZUPAN, Samo, ŽEROVNIK, Andrej, PREBIL, Ivan. Simulacija naleta osebnega in tovornega vozila na betonsko vzdolžno steno, utrjeno tlakovano brežino ter obcestni robnik premostitvenega objekta : končno poročilo. Ljubljana: Fakulteta za strojništvo, Katedra za modeliranje v tehniki in medicini, 2017. 50 f., ilustr. [COBISS.SI-ID [15285019](#)]

Simon Krašna:

1. Prebil I., **Krašna S.**, Ciglarič I.: Synthesis of four-bar mechanism in a hydraulic support using a global optimization algorithm. Structural and multidisciplinary optimization, Letn. 24, št. 3, str. 246-251. [COBISS.si-ID [5378331](#)]

2. **Krašna S.** ; Prebil I., Hribernik M.: Human body modelling for traffic accident analysis. Vehicle System Dynamics, Letn. 45, št. 10, str. 969-980. [COBISS.si-ID [10252315](#)]
3. **Krašna S.**; Djordjević S., Hribernik M.; Trajkovski A.: A novel approach to measuring muscle mechanics in vehicle collision conditions. Sensors, Vol. 17, iss. 6, F. 1-17. [COBISS.si-ID [15539483](#)]
4. **Krašna S.**, Keller A., Linder A., Silvano A.P., Xu J.-C.; Thomson R.; Klug C.: Human response to longitudinal perturbations of standing passengers on public transport during regular operation. Frontiers in bioengineering and biotechnology, Vol. 9, 2021, str. 1-15. [COBISS.si-ID [83440131](#)]
5. **Krašna S.**: Predloge k predavanjem [Elektronski vir] : Mehanizmi, II. stopnja; gradivo za lažje spremljanje predavanj. Drugo učno gradivo, 2016. [COBISS.si-ID [14567963](#)]
6. **Krašna S.**: Zbirka rešenih nalog [Elektronski vir] : dodatno učno gradivo za predmet Mehanizmi, II. Stopnja. Drugo učno gradivo, 2016. [COBISS.si-ID [14568219](#)]