

DINAMIKA SISTEMOV TELES

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	DINAMIKA SISTEMOV TELES
Course title:	DYNAMICS OF MULTIBODY SYSTEMS
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo, tretja stopnja, doktorski	Konstrukcijsko mehanske inženirske znanosti (smer)		Celoletni	izbirni

Univerzitetna koda predmeta/University course code:	0033429
Koda učne enote na članici/UL Member course code:	7103

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
90					160	10

Nosilec predmeta/Lecturer:	Miha Boltežar
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Izvajalci predavanj:	Miha Boltežar, Gregor Čepin
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course	Izbirni predmet /Elective course
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type:

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Jeziki/Languages:

Predavanja/Lectures:	Angleščina, Slovenščina
Vaje/Tutorial:	Angleščina, Slovenščina

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

Prerequisites:

Veljajo splošni pogoji za doktorski študij.	General prerequisites for the third level studies.
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Vsebina:

Content (Syllabus outline):

<p>Uvod, kinematika v nepremičnem in premičnem koordinatnem sistemu, rotacijske matrike.</p> <p>Analitični pristop: posplošene koordinate in kinematične vezi, Lagrangeova dinamika, Eulerjeve enačbe za primer večih spremenljivk.</p> <p>Zapis dinamskih enačb v premičnem koordinatnem sistemu: kinematika, vztrajnost deformabilnih teles, posplošene sile, uporaba neodvisnih koordinat, dinamske enačbe z multiplikatorji.</p> <p>Dinamske enačbe za primer velikih deformacij, uporaba absolutnega koordinatnega sistema, postavitve togostne matrike.</p> <p>Aplikacija na računsko dinamiko sistemov togih ter prožnih teles. Uporaba v sodobnem inženirstvu.</p> <p>Dinamika sistemov togih teles z enostranskimi kontakti: kontaktna kinematika, primer večih sočasnih trkov, sočasno upoštevanje trka ter trenja v kontaktu. Linearni komplementarni problem. Numerično reševanje. Aplikacije v strojništvu.</p>	<p>Introduction, kinematics in the fixed and moving reference frame, rotational matrices.</p> <p>Analytic approach: generalised coordinates and kinematical constraints, Lagrangian dynamics, Euler equations in the case of several variables.</p> <p>Dynamic equations in the moving reference frame: kinematics, inertia of deformable bodies, generalised forces, the use of generalised coordinates, dynamic equations with multipliers.</p> <p>Dynamic equations in the case of big deformations, absolute nodal coordinate system, determination of stiffness matrix.</p> <p>Application to computational dynamics of systems of rigid and flexible bodies. Applications in modern engineering.</p> <p>Dynamics of rigid bodies with unilateral contacts: contact kinematics, several simultaneous impacts, simultaneous description of friction and impact. Linear complementarity problem. Numerical aspects. Application in mechanical engineering.</p>
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Temeljna literatura in viri/Readings:

[1] A. A. Shabana: Computational Dynamics, John Wiley & Sons, 1994. - izbrana poglavja
[2] F. Pfeiffer, C. Glocker: Multibody Dynamics with Unilateral Contacts, John

Wiley &

Sons, 1996.

[3] A. A. Shabana: Dynamics of Multibody Systems, 3rd ed., Cambridge university press, 1994. – izbrana poglavja

[4] A. A. Shabana: Computational Continuum Mechanics, Cambridge University Press, 2008.

Cilji in kompetence:

Cilji:

Študentu prikazati vlogo in pomen sodobnih metod pri obvladovanju gibanja sistemov togih ter prožnih teles ter poudariti njihovo uporabo.

Kompetence:

Študent osvoji potrebna znanja iz kinematike in dinamike sistemov teles, potrebna za samostojno kreiranje gibalnih enačb, na podlagi katerih je v nadaljevanju omogočena numerična rešitev danega problema.

Objectives and competences:

Goals:

The principal goal is to demonstrate and learn modern analytical methods in the field of multibody system dynamics composed of rigid and flexible bodies.

Competences:

Student learns kinematical and dynamical principles in the field of multibody dynamics that enables him (her) to individually derive the governing equations of motion that further lead to numerical solution of the problem.

Predvideni študijski rezultati:

Študent osvoji potrebna znanja iz kinematike in dinamike sistemov teles, potrebna za samostojno kreiranje gibalnih enačb, na podlagi katerih je v nadaljevanju omogočena numerična rešitev danega problema.

Intended learning outcomes:

Student learns kinematical and dynamical principles in the field of multibody dynamics that enables him (her) to individually derive the governing equations of motion that further lead to numerical solution of the problem.

Metode poučevanja in učenja:

Predavanja, laboratorijske vaje, seminarsko delo, e-izobraževanje, konzultacije. Seminarsko delo v čim večji meri navezuje se na področje doktorskega raziskovanja. Študij z uporabo priporočene literature.

Learning and teaching methods:

Lectures, laboratory practice & seminar work, e-education, consulting. The seminar work is related, as much as possible, to the student's doctoral research field. Study on a recommended literature basis.

Načini ocenjevanja:

Delež/ Weight

Assessment:

Ustni izpit (50%), poročilo o seminarskem delu (50%). Pogoj

Oral exam (50%), report on seminar work (50%). The

za opravljanje ustnega izpita je uspešno izdelano in pozitivno ocenjeno seminarsko delo.	condition for admission to oral exam is successful completion of seminar work, rewarded with a passing grade.
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Reference nosilca/Lecturer's references:

prof. dr. Miha Boltežar

LANGERHOLC, Marko, SLAVIČ, Janko, BOLTEŽAR, Miha. Absolute nodal coordinates in digital image correlation. *Experimental mechanics*, ISSN 0014-4851. Tiskana izd., 2013, vol. 53, issue 5, str. 807-818, ilustr., doi: 10.1007/s11340-012-9691-4.

LANGERHOLC, Marko, SLAVIČ, Janko, BOLTEŽAR, Miha. A thick anisotropic plate element in the framework of an absolute nodal coordinate formulation. *Nonlinear dynamics*, ISSN 0924-090X, 2013, vol. 73, issue 1-2, str. 183-198, ilustr., doi: 10.1007/s11071-013-0778-y.

ČEPON, Gregor, BOLTEŽAR, Miha. Dynamics of a belt-drive system using a linear complementarity problem for the belt-pulley contact description. *Journal of sound and vibration*, ISSN 0022-460X. [Print ed.], Jan. 2009, vol. 319, iss. 3/5, str. 1019-1035. <http://dx.doi.org/10.1016/j.jsv.2008.07.005>, doi: 10.1016/j.jsv.2008.07.005.

ŽUMER, Jurij, SLAVIČ, Janko, BOLTEŽAR, Miha. Minimization of the positional errors for an accurate determination of the kinematic parameters of a rigid-body system with miniature inertial sensors. *Mechanism and Machine Theory*, ISSN 0094-114X. [Print ed.], Nov. 2014, vol. 81, str. 193-208, ilustr., doi: 10.1016/j.mechmachtheory.2014.07.008.

izr.prof.dr. Gregor Čepon

ČEPON, Gregor, ROGELJ, Jakob, KNEZ, Luka, BOLTEŽAR, Miha. On multibody-system equilibrium-point selection during joint-parameter identification: A numerical and experimental analysis. *Mechanism and machine theory*. Oct. 2018, vol. 128, str. 287-297, ilustr. ISSN 0094-114X.

<https://reader.elsevier.com/reader/sd/4DD5CFA769E4844C44957DC23A00BB0E4308D3BB4E503DF73B8751DAFE5811AE828E9444284C0DCDA803F3C3F90A1445>, DOI: [10.1016/j.mechmachtheory.2018.06.006](https://doi.org/10.1016/j.mechmachtheory.2018.06.006). [COBISS.SI-ID [16120347](https://cobiss.si/16120347)], [JCR, SNIP]

ČEPON, Gregor, STARC, Blaž, ZUPANČIČ, Blaž, BOLTEŽAR, Miha. Coupled thermo-structural analysis of a bimetallic strip using the absolute nodal coordinate formulation. *Multibody system dynamics*. Dec. 2017, vol. 41, iss. 4, f. 391-402, ilustr. ISSN 1384-5640. <https://link.springer.com/article/10.1007%2Fs11044-017-9574-7>, DOI: [10.1007/s11044-017-9574-7](https://doi.org/10.1007/s11044-017-9574-7). [COBISS.SI-ID [15513627](https://cobiss.si/15513627)], [JCR, SNIP, WoS do 3. 12. 2019: št. citatov (TC): 2, čistih citatov (CI): 2, Scopus do 29. 2. 2020: št. citatov (TC): 5, čistih citatov (CI): 5]

ČEPON, Gregor, MANIN, Lionel, BOLTEŽAR, Miha. Validation of a flexible multibody belt-drive model. *Strojniški vestnik*. jul.-avg. 2011, vol. 57, no. 7/8, str. 539-546, ilustr. ISSN 0039-2480. DOI: [10.5545/sv-jme.2010.257](https://doi.org/10.5545/sv-jme.2010.257). [COBISS.SI-ID [11951131](https://cobiss.si/11951131)], [JCR, SNIP, WoS do 3. 12. 2019: št. citatov (TC): 6, čistih citatov (CI): 5, Scopus do 3. 12. 2019: št. citatov (TC): 10, čistih citatov (CI): 9]

ČEPON, Gregor, MANIN, Lionel, BOLTEŽAR, Miha. Experimental identification of

the contact parameters between a V-ribbed belt and a pulley. *Mechanism and machine theory*. Oct. 2010, vol. 45, iss. 10, str. 1424-1433. ISSN 0094-114X. DOI: [10.1016/j.mechmachtheory.2010.05.006](https://doi.org/10.1016/j.mechmachtheory.2010.05.006). [COBISS.SI-ID [11450651](#)], [JCR, SNIP, WoS do 3. 12. 2019: št. citatov (TC): 20, čistih citatov (CI): 19, Scopus do 23. 12. 2019: št. citatov (TC): 30, čistih citatov (CI): 29]

ČEPON, Gregor, BOLTEŽAR, Miha. Dynamics of a belt-drive system using a linear complementarity problem for the belt-pulley contact description. *Journal of sound and vibration*. [Print ed.]. Jan. 2009, vol. 319, iss. 3/5, str. 1019-1035. ISSN 0022-460X. <http://dx.doi.org/10.1016/j.jsv.2008.07.005>, DOI: [10.1016/j.jsv.2008.07.005](https://doi.org/10.1016/j.jsv.2008.07.005). [COBISS.SI-ID [10609947](#)], [JCR, SNIP, WoS do 19. 1. 2020: št. citatov (TC): 39, čistih citatov (CI): 27, Scopus do 22. 1. 2020: št. citatov (TC): 53, čistih citatov (CI): 40]

ČEPON, Gregor, MANIN, Lionel, BOLTEŽAR, Miha. Introduction of damping into the flexible multibody belt-drive model : a numerical and experimental investigation. *Journal of sound and vibration*. [Print ed.]. 2009, vol. 324, iss. 1/2, str. 283-296, ilustr. ISSN 0022-460X. DOI: [10.1016/j.jsv.2009.02.001](https://doi.org/10.1016/j.jsv.2009.02.001). [COBISS.SI-ID [10936603](#)], [JCR, SNIP, WoS do 3. 12. 2019: št. citatov (TC): 26, čistih citatov (CI): 20, Scopus do 22. 12. 2019: št. citatov (TC): 39, čistih citatov (CI): 32]

ČEPON, Gregor, BOLTEŽAR, Miha. Computing the dynamic response of an axially moving continuum. *Journal of sound and vibration*. [Print ed.]. 2007, letn. 300, št. 1/2, str. 316-329. ISSN 0022-460X. <http://dx.doi.org/10.1016/j.jsv.2006.08.014>. [COBISS.SI-ID [9771035](#)], [JCR, SNIP, WoS do 3. 12. 2019: št. citatov (TC): 24, čistih citatov (CI): 20, Scopus do 20. 2. 2020: št. citatov (TC): 30, čistih citatov (CI): 25]

RAZPOTNIK, Matej, ČEPON, Gregor, BOLTEŽAR, Miha. A Smooth contact-state transition in a dynamic model of rolling-element bearings. *Journal of sound and vibration*. [Print ed.]. Sep. 2018, vol. 430, str. 196-213, ilustr. ISSN 0022-460X. https://ac.els-cdn.com/S0022460X18303316/1-s2.0-S0022460X18303316-main.pdf?_tid=0053fe6d-b9b1-479b-9db2-02f142a55b55&acdnat=1528357961_a6804519835b68bd2d06a119a4e9a336, DOI: [10.1016/j.jsv.2018.05.041](https://doi.org/10.1016/j.jsv.2018.05.041). [COBISS.SI-ID [16096795](#)], [JCR, SNIP, WoS do 15. 12. 2019: št. citatov (TC): 1, čistih citatov (CI): 1, Scopus do 3. 12. 2019: št. citatov (TC): 1, čistih citatov (CI): 1]