

DINAMIKA IN VIBRACIJE

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	DINAMIKA IN VIBRACIJE
Course title:	DYNAMICS AND VIBRATIONS
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo, tretja stopnja, doktorski	Konstrukcijsko mehanske inženirske znanosti (smer)	1. letnik, 2. letnik	Celoletni	izbirni

Univerzitetna koda predmeta/University course code:	0033428
Koda učne enote na članici/UL Member course code:	7102

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

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

Vrsta predmeta/Course type:

Izbirni predmet /Elective course

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.

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

Nihanja linearnih sistemov z več prostostnimi stopnjami. Modalna transformacija. Odziv sistemov v glavnih koordinatah.

Nihanja zveznih sistemov, analitične in približne metode. Osnove nihanj nelinearnih sistemov. Vibracijska testiranja.

Eksperimentalni pristop pri obvladovanju vibracij. Analiza dinamskih spremenljivk v časovnem in frekvenčnem prostoru.

Kriteriji stabilnosti gibanja.

Dinamika rotorjev, izračun kritičnih vrtilnih hitrosti. Masno uravnotežanje rotorjev.

Dinamika batnih strojev.

Preračun vibroizolacije elastično podprtih motorjev.

Torzijska nihanja gredi. Osnove nihanj plošč, nihanje rotirajočih palic.

Slučajna nihanja linearnih sistemov. Obdelava in vrednotenje izmerjenih slučajnih nihanj. Interakcija človek – vibracije.

Vibrations of linear systems with several degrees-of-freedom. Modal transformation. The response of the system in modal coordinates.

Vibrations of continuous systems, analytical and approximate methods. The basic principles of nonlinear vibrations.

Vibration testing.

Experimental work in vibrations. Analysis of measured variables in the time and frequency domains.

Dynamic stability.

Rotor dynamics, determination of critical speed of rigid and flexible rotors. Mass balancing of rotors.

Dynamics of reciprocating engines.

Vibroisolations of elastically mounted engines.

Torsional vibrations of shafts. Basics of vibrations of plates, vibrations of rotating bars.

Random vibrations, theoretical and experimental aspects.

Human response to vibrations.

Temeljna literatura in viri/Readings:

[1] Rao SS: Mechanical vibration, 6th Ed, 2018. COBISS.SI-ID - 138737667

[2] Rao, J.S.: Dynamics of plates.- New York; Basel; Hong Kong: M. Dekker; New

Delhi etc.: Narosa, cop. 1999. COBISS.SI-ID - 3548443
 [3] Frolov, K.V., Furman, F.A.: Applied theory of vibration isolation systems.- New York etc.: Hemisphere, 1990. COBISS.SI-ID - 177947
 [4] McConnell, K.G.: Vibration testing: theory and practice.- New York etc.: John Wiley & Sons, cop. 2008. COBISS.SI-ID - 12112155
 [5] Lee, Chong-Won: Vibration analysis of rotors.- Dordrecht; Boston; London: Kluwer Academic, cop. 1993.- (Solid mechanics and its applications; vol. 21). COBISS.SI-ID - 742683
 [6] Newland DE: An Introduction to Random Vibrations, Spectral & Wavelet Analysis, 3rd Ed, 2005. COBISS.SI-ID - 3552795
 [7] Griffin, M.J.: Handbook of human vibration - 2nd ed.- London etc.: Academic Press, 1994, cop. 1990. - Izbrana poglavja. COBISS.SI-ID - 2127211

Cilji in kompetence:

Cilji:

Cilji predmeta so nagradnja znanj iz druge stopnje na področju dinamike ter vibracij za doseg sposobnosti samostojnega reševanja specialne problematike, tako v fazi razvoja izdelkov, njihovi izdelavi kot tudi pri transportu ter vzdrževanju.

Kompetence:

Študent postane sposoben identifikacije, modeliranja ter merjenja tipičnih dinamskih pojavov v strojništvu. To so predvsem nihanja realnih sistemov z več prostostnimi stopnjami, zagotavljanje ustrezne vibroizolacije za zaščito naprav ter okolice, razumevanje problematike vibracijskih testiranj.

Objectives and competences:

Goals:

The aim of the course is to upgrade the previously learned knowledge in the field of dynamics and vibrations in order to achieve the level of independent researcher in the design phase of the products, manufacturing phase as well as at transport and maintenance.

Competences:

The student acquires specific knowledge of identification, modelling and experimentation of typical dynamic phenomena in mechanical engineering, connected to mechanical vibrations. This includes specifically vibrations of multi-degree-of-freedom systems, vibroisolation to protect machinery and environment and understanding of vibration testing.

Predvideni študijski rezultati:

Študent postane sposoben identifikacije, modeliranja ter merjenja tipičnih dinamskih pojavov v strojništvu. To so predvsem nihanja realnih sistemov z več prostostnimi stopnjami, zagotavljanje ustrezne vibroizolacije za zaščito naprav ter okolice, razumevanje problematike vibracijskih testiranj.

Intended learning outcomes:

The student acquires specific knowledge of identification, modelling and experimentation of typical dynamic phenomena in mechanical engineering, connected to mechanical vibrations. This includes specifically vibrations of multi-degree-of-freedom systems, vibroisolation to protect machinery and environment and understanding of vibration testing.

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%). Pogoji za opravljanje ustnega izpita je uspešno izdelano in pozitivno ocenjeno seminarsko delo.

Oral exam (50%), report on seminar work (50%). The condition for admission to oral exam is successful completion of seminar work, rewarded with a passing grade.

Ocenjevalna lestvica:**Grading system:**

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:**prof. dr. Miha Boltežar**

ČESNIK, Martin, SLAVIČ, Janko, BOLTEŽAR, Miha. Accelerated vibration-fatigue characterization for 3D-printed structures : application to fused-filament-fabricated PLA samples. *International journal of fatigue*, ISSN 0142-1123, Feb. 2023, str. 1-38, ilustr. <https://www.sciencedirect.com/science/article/pii/S0142112323000750>, doi: [10.1016/j.ijfatigue.2023.107574](https://doi.org/10.1016/j.ijfatigue.2023.107574). [COBISS.SI-ID [141842691](https://www.cobiss.si/id/141842691)]

ZORMAN, Aleš, SLAVIČ, Janko, BOLTEŽAR, Miha. Vibration fatigue by spectral methods : a review with open-source support. *Mechanical systems and signal processing*, ISSN 1096-1216, May 2023, vol. 190, str. 1-23, ilustr. <https://www.sciencedirect.com/science/article/pii/S0888327023000560>, doi: [10.1016/j.ymssp.2023.110149](https://doi.org/10.1016/j.ymssp.2023.110149). [COBISS.SI-ID [141052419](https://www.cobiss.si/id/141052419)],

KODRIČ, Miha, ČEPON, Gregor, BOLTEŽAR, Miha. Expansion of the dynamic strain field in 3D-printed structures using a hybrid modeling approach. *Measurement : journal of the International Measurement Confederation*, ISSN 0263-2241. [Print ed.], Jan. 2023, vol. 206, str. 1-10, ilustr. <https://www.sciencedirect.com/science/article/pii/S0263224122015354>, doi: [10.1016/j.measurement.2022.112339](https://doi.org/10.1016/j.measurement.2022.112339). [COBISS.SI-ID [134914563](https://www.cobiss.si/id/134914563)].

OBLAK, Miša, PIRNAT, Miha, BOLTEŽAR, Miha. Modal-interaction approach to the strong structural-acoustic coupling of an elastic Helmholtz resonator and an acoustic cavity containing a heavy fluid. *Journal of sound and vibration*, ISSN 0022-460X. [Print ed.], Sep. 2022, vol. 535, str. 1-17, ilustr. <https://www.sciencedirect.com/science/article/pii/S0022460X2200325X>, doi: [10.1016/j.jsv.2022.117120](https://doi.org/10.1016/j.jsv.2022.117120). [COBISS.SI-ID [112492035](https://www.cobiss.si/id/112492035)].

prof. dr. Janko Slavič

ČESNIK, Martin, SLAVIČ, Janko, BOLTEŽAR, Miha. Accelerated vibration-fatigue characterization for 3D-printed structures : application to fused-filament-fabricated PLA samples. *International journal of fatigue*. Feb. 2023, str. 1-38, ilustr. ISSN 0142-1123. <https://www.sciencedirect.com/science/article/pii/S0142112323000750>, DOI: [10.1016/j.ijfatigue.2023.107574](https://doi.org/10.1016/j.ijfatigue.2023.107574). [COBISS.SI-ID [141842691](https://cobiss.si/141842691)], [JCR, SNIP] kategorija: 1A1 (Z, A', A1/2); uvrstitev: SCIE, Scopus, MBP (INSPEC, COMPENDEX); tip dela še ni verificiran
točke: 41.36, št. avtorjev: 3

BARŠI PALMIČ, Tibor, SLAVIČ, Janko. Design principles for a single-process 3D-printed stacked dielectric actuators : theory and experiment. *International journal of mechanical sciences*. May 2023, vol. 246, str. 1-16, ilustr. <https://www.sciencedirect.com/science/article/pii/S0020740323000309>, DOI: [10.1016/j.jimecsci.2023.108128](https://doi.org/10.1016/j.jimecsci.2023.108128). [COBISS.SI-ID [139541763](https://cobiss.si/139541763)], [JCR, SNIP, WoS, Scopus] kategorija: 1A1 (Z, A', A1/2); uvrstitev: SCIE, Scopus, MBP (INSPEC, COMPENDEX); tip dela je verificiral OSICT točke: 70.43, št. avtorjev: 2

ZALETELJ, Klemen, GORJUP, Domen, SLAVIČ, Janko, BOLTEŽAR, Miha. Multi-level curvature-based parametrization and model updating using a 3D full-field response. *Mechanical systems and signal processing*. 2023, vol. 187, str. 1-15, ilustr. ISSN 0888-3270. <https://www.sciencedirect.com/science/article/pii/S0888327022009955>, DOI: [10.1016/j.ymssp.2022.109927](https://doi.org/10.1016/j.ymssp.2022.109927). [COBISS.SI-ID [130115331](https://cobiss.si/130115331)], [JCR, SNIP, WoS, Scopus] kategorija: 1A1 (Z, A'', A', A1/2); uvrstitev: SCIE, Scopus, MBP (INSPEC, COMPENDEX); tip dela je verificiral OSICN točke: 40.76, št. avtorjev: 4

ZORMAN, Aleš, SLAVIČ, Janko, BOLTEŽAR, Miha. Vibration fatigue by spectral methods : a review with open-source support. *Mechanical systems and signal processing*. May 2023, vol. 190, str. 1-23, ilustr. ISSN 1096-1216. <https://www.sciencedirect.com/science/article/pii/S0888327023000560>, DOI: [10.1016/j.ymssp.2023.110149](https://doi.org/10.1016/j.ymssp.2023.110149). [COBISS.SI-ID [141052419](https://cobiss.si/141052419)], [JCR, SNIP] kategorija: 1A1 (Z, A'', A', A1/2); uvrstitev: SCIE, Scopus, MBP (INSPEC, COMPENDEX); tip dela je verificiral OSICN točke: 54.35, št. avtorjev: 3

izr. prof. dr. Gregor Čepon

ČEPON, Gregor, OCEPEK, Domen, KORBAR, Jure, BREGAR, Tomaž, BOLTEŽAR, Miha. Sensitivity-based characterization of the bias errors in frequency based substructuring. *Mechanical systems and signal processing*. May 2022, vol. 170, str. 1-18, ilustr. ISSN 0888-3270. <https://www.sciencedirect.com/science/article/pii/S0888327021011092?dgcid=author>, DOI: [10.1016/j.ymssp.2021.108800](https://doi.org/10.1016/j.ymssp.2021.108800). [COBISS.SI-ID [97635843](https://cobiss.si/97635843)], [JCR, SNIP, Scopus]

BREGAR, Tomaž, ZALETELJ, Klemen, ČEPON, Gregor, SLAVIČ, Janko, BOLTEŽAR, Miha. Full-field FRF estimation from noisy high-speed-camera data using a dynamic substructuring approach. *Mechanical systems and signal processing*. Mar. 2021, vol. 150, str. 1-12, ilustr. ISSN 0888-3270. <https://www.sciencedirect.com/science/article/pii/S088832702030649X?via%3Dihub>, DOI: [10.1016/j.ymssp.2020.107263](https://doi.org/10.1016/j.ymssp.2020.107263). [COBISS.SI-ID [31276803](https://cobiss.si/31276803)],

[JCR, SNIP, WoS do 7. 2. 2023: št. citatov (TC): 19, čistih citatov (CI): 14, čistih citatov na avtorja (CIAu): 2,80, Scopus do 14. 2. 2023: št. citatov (TC): 19, čistih citatov (CI): 13, čistih citatov na avtorja (CIAu): 2,60]

KODRIČ, Miha, ČEPON, Gregor, BOLTEŽAR, Miha. Expansion of the dynamic strain field in 3D-printed structures using a hybrid modeling approach. *Measurement : journal of the International Measurement Confederation*. [Print ed.]. Jan. 2023, vol. 206, str. 1-10, ilustr. ISSN 0263-2241. <https://www.sciencedirect.com/science/article/pii/S0263224122015354>, DOI: 10.1016/j.measurement.2022.112339. [COBISS.SI-ID 134914563], [JCR, SNIP, WoS, Scopus]

OCEPEK, Domen, ČEPON, Gregor, BOLTEŽAR, Miha. Characterization of sensor location variations in admittance-based TPA methods. *Journal of sound and vibration*. [Print ed.]. Jun. 2022, vol. 528, str. 1-15, ilustr. ISSN 0022-460X. <https://www.sciencedirect.com/science/article/pii/S0022460X22001298>, DOI: 10.1016/j.jsv.2022.116888. [COBISS.SI-ID 102695939], [JCR, SNIP, WoS do 26. 10. 2022: št. citatov (TC): 1, čistih citatov (CI): 0, čistih citatov na avtorja (CIAu): 0,00, Scopus do 14. 2. 2023: št. citatov (TC): 1, čistih citatov na avtorja (CIAu): 0,00]