

NELINEARNA NIHANJA STRUKTUR

UČNI NAČRT PREDMETA/COURSE SYLLABUS

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| Predmet: | NELINEARNA NIHANJA STRUKTUR |
| Course title: | NONLINEAR STRUCTURAL DYNAMICS |
| 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 |

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| Univerzitetna koda predmeta/University course code: | 0033435 |
| Koda učne enote na članici/UL Member course code: | 7110 |

| 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 |

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

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| Vrsta predmeta/Course | Izbirni predmet /Elective course |
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type:

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Jeziki/Languages:

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

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

Prerequisites:

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

Content (Syllabus outline):

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| <p>Eksperimentalna modalna analiza, obratovalna modalna analiza. Identifikacija ter obravnavanje lokaliziranih nelinearnosti v kompleksnih strukturah ter njihovo veljavno modeliranje.</p> <p>Spektralne analize pri eksperimentalnem delu v dinamiki. Neparametrične in parametrične metode. Fourierjeva razčlemba v frekvenčnem prostoru, diskretna Fourierjeva transformacija.</p> <p>Uporaba spektralnih analiz višjih redov za detekcijo nelinearnosti s poudarkom na bispektralnih ter bikoherenčnih analizah. Problem kvalitete cenilk.</p> <p>Uporaba valčnih analiz za nestacionarno dinamiko. Določevanje lastnih frekvenc, modalnega dušenja ter lastnih oblik z uporabo zvezne valčne transformacije.</p> <p>Modeliranje ter identifikacija strukturnega dušenja.</p> <p>Problematika robnih in vmesnih pogojev, modeliranje ter identifikacija.</p> <p>Obravnavanje dinamike v faznem prostoru, pravem ter rekonstruiranem.</p> <p>Določevanje nelinearnih lastnih oblik.</p> <p>Uporaba nelinearne dinamike struktur v tehniških sistemih za prepoznavo napak ter vibracijskega obnašanja.</p> | <p>Experimental modal analysis, operational modal analysis. Identification and modelling of localised nonlinearities in complex structures and their valid modelling.</p> <p>Spectral analysis at experimental work in structural dynamics. Non-parametric and parametric methods. Fourier decomposition of signals, discrete Fourier transform.</p> <p>Higher order spectral analyses to detect nonlinearities in the time series. Bispectral and bicoherence analyses. The quality of estimates.</p> <p>Continuous wavelet transform in nonstationary dynamics. Modal parameters estimation using continuous wavelet transform.</p> <p>Identification and modelling of structural damping.</p> <p>Boundary and intermediate conditions, identification and modelling.</p> <p>Nonlinear dynamics in the phase space, real and reconstructed. Nonlinear normal modes.</p> <p>Nonlinear structural dynamics in order to detect faults in products. The design aspects of end-of-line control devices.</p> |
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Temeljna literatura in viri/Readings:

- [1] N.M.M.Maia, J.M.M.Silva: Theoretical and Experimental Modal Analysis, Research Studies Press, 1997 – izbrana poglavja
- [2] K. Worden, G.R. Tomlinson: Nonlinearity in Structural Dynamics: Detection, Identification and Modelling, IoP Publishing, 2001
- [3] S. Braun: Discover Signal Processing, An Interactive Guide for Engineers, John Wiley & Sons, 2008
- [4] K Shin, J.K.Hammond: Fundamentals of Signal Processing for Sound and Vibration Engineers, John Wiley & Sons, 2008
- [5] A.H. Nayfeh, D. Mook: Nonlinear Oscillations, John Wiley & Sons, 1995– izbrana poglavja
- [6] S. Mallat: A Wavelet Tour of Signal Processing, 2nd ed., Academic Press, 2001– izbrana poglavja
- [7] Nikias C.L. , A. Petropulu: Higher order spectra analysis, a nonlinear signal processing framework, Prentice Hall, 1993

Cilji in kompetence:

Cilji:

Študentu prikazati vlogo in pomen znanja iz specifičnih dinamskih pojavov, katerih obvladovanje je potrebno za načrtovanje realnih inženirskih izdelkov, ki vsebujejo tudi gibajoče dele oz. so podvrženi dinamičnim obremenitvam. Posebej so poudarjena znanja za vibracijsko obvladovanje izdelkov v avtomobilski industriji.

Kompetence:

Študent osvoji poglobljena znanja iz nihanja struktur, potrebna za obvladovanje vibracijskega obnašanja inženirskih izdelkov. Pri tem je dan poudarek na dinamskem obvladovanju robnih ter vmesnih pogojev takih struktur ter njihovem veljavnemu modeliranju. Vse to omogoča razvoj izdelkov, še posebej na področju avtomobilske industrije ter transporta nasploh, za doseg čim mirnejšega ter čim tišjega dolgotrajnega obratovanja.

Objectives and competences:

Goals:

The aim of the course is to demonstrate specific knowledge of structural vibrations, needed when designing real engineering products that contain moving parts or are subjected to dynamic loading. The core of the course is specifically aimed at products for automotive industry.

Competences:

Student gains specific knowledge needed to control vibrational behaviour of engineering products. Some additional aspects include boundary and intermediate conditions of the structures and their valid modelling. This allows one to design the products specifically in the automotive and other transport industry, to achieve as durable and as quiet behaviour as possible.

Predvideni študijski rezultati:

Študent osvoji poglobljena znanja iz nihanja struktur, potrebna za

Intended learning outcomes:

Student gains specific knowledge needed to control vibrational behaviour

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| obvladovanje vibracijskega obnašanja inženirskih izdelkov. Pri tem je dan poudarek na dinamskem obvladovanju robnih ter vmesnih pogojev takih struktur ter njihovemu veljavnemu modeliranju. Vse to omogoča razvoj izdelkov, še posebej na področju avtomobilske industrije ter transporta nasploh, za doseg čim mirnejšega ter čim tišjega dolgotrajnega obratovanja. | of engineering products. Some additional aspects include boundary and intermediate conditions of the structures and their valid modelling. This allows one to design the products specifically in the automotive and other transport industry, to achieve as durable and as quiet behaviour as possible. |
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Metode poučevanja in učenja:

Learning and teaching methods:

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| 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. | 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. |
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Načini ocenjevanja:

Delež/ Weight

Assessment:

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| 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. |
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Reference nosilca/Lecturer's references:

prof. dr. Miha BOLTEŽAR

KRANJC, Tadej, SLAVIČ, Janko, BOLTEŽAR, Miha. An interface force measurements-based substructure identification and an analysis of the uncertainty propagation. Mechanical systems and signal processing, ISSN 0888-3270. [Tiskana izd.], May 2015, vol. 56/57, str. 2-14, ilustr., doi: 10.1016/j.ymssp.2014.11.005.

ROVŠČEK, Domen, SLAVIČ, Janko, BOLTEŽAR, Miha. Operational mode-shape normalisation with a structural modification for small and light structures. Mechanical systems and signal processing, ISSN 0888-3270. [Tiskana izd.], 2014, vol. 42, issue 1-2, str. 1-13, doi: 10.1016/j.ymssp.2013.08.019.

KRANJC, Tadej, SLAVIČ, Janko, BOLTEŽAR, Miha. A comparison of strain and classic experimental modal analysis. Journal of vibration and control, ISSN 1077-5463. [Tiskana izd.], 2014, str. 1-11, ilustr., doi: 10.1177/1077546314533137.

ČESNIK, Martin, SLAVIČ, Janko, ČERMELJ, Primož, BOLTEŽAR, Miha. Frequency-based structural modification for the case of base excitation. Journal of sound and vibration, ISSN 0022-460X. [Print ed.], 2013, vol. 332, issue 20, str. 5029-5039, ilustr., doi: 10.1016/j.jsv.2013.04.038.

