

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Uvod v akustiko
Course title:	INTRODUCTION TO ACOUSTICS
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Energetsko strojništvo (smer)	2. letnik	2. semester

Univerzitetna koda predmeta/University course code:	0562720
Koda učne enote na članici/UL Member course code:	3023-V

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
30		30			40	4

Nosilec predmeta/Lecturer:	Jurij Prezelj
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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:
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):
<p>1. Uvod:</p> <ul style="list-style-type: none"> - Definicija zvoka v zraku, infrazvok, ultrazvok, zvok v kapljevinah, akustična emisija; - Akustika v zraku in kapljevini z vidika termodinamike in mehanike fluidov na kratki časovni skali; - Človeški sluh in percepcija zvoka, kako hrup škodi zdravju in zakaj ga je potrebno obvladovati; - Uporabnost akustike pri spremljanju delovanja strojev naprav in procesov; - Zakaj imajo akustično obdelani izdelki prednost pred konkurenco, ekonomski vidik akustike. 	<p>1. Introduction:</p> <ul style="list-style-type: none"> - Definition of sound in air, infrasound, ultrasound, sound in liquids, acoustic emission; - Acoustics in air and liquid based on thermodynamics and fluid mechanics in a short time scale; - Human hearing and sound perception, how noise damages health and why it needs to be managed; - Applications of acoustics in monitoring the performance of machines, devices and different processes; - Why acoustically treated products have advantage

<p>2. Izvori zvoka:</p> <ul style="list-style-type: none"> - Osnovni fizikalni mehanizmi generiranja zvoka v zraku (aerodinamični, vibroakustični, termični); - Povezava zvoka s termodinamiko prikazana na primeru izpeljave hitrosti širjenja motnje po različnih medijih; - Longitudinalno in transferzalno valovanje; - Eulerjeva poenostavljena oblika enačbe gibanja fluida; - Opis valovne enačbe za 1D širjenje zvočnega valovanja in razlaga njenih rešitve v domeni čas prostor; - Korelacija med časovno in krajevno koordinato polja zvočnega tlaka. <p>3. Širjenje zvoka:</p> <ul style="list-style-type: none"> - Akustična impedanca - povezava med zvočnim tlakom in gibanjem delcev; - Huygenov opis uklona, odboja in sipanja zvočnega valovanja; - Prehod iz 1D zvočnega valovanja $p(x, t)$ v 3D zvočno valovanje $p(x, y, z, t)$, v Sferično valovanje $p(r, t)$; - Pomen razmerja med valovno dolžino in velikostjo geometrije prostora oziroma ovire na poti širjenja zvoka ($k=2\pi/\lambda$, k_r, k_x); - Zvočni tlak kot posledica volumskega pretoka skozi točko kot zvočni vir; - Bližnje in daljno polje sferičnega zvočnega vira; - Realni zvočni viri in njihova primerjava preko velikostnih razredov. <p>4. Akustični merilni sistem:</p> <ul style="list-style-type: none"> - Delovanje mikrofонов, linearnost po amplitudi, linearnost po frekvenčnem območju; - Kalibracija mikrofонов do SI enot; - Mikrofonski signal, delovna kalibracija mikrofонов, efektivna vrednost in njene časovne konstante; - Definicija ravni in enote decibel za opis amplitude zvočnih signalov, ekvivalentna vrednost kot statistična značilka; - Oktavni in terčni spektri, filtriranje signalov, FIR filter, FFT; - Frekvenčno uteženje po "A", "B" in "C" krivuljah. <p>5. Zvočna polja:</p> <ul style="list-style-type: none"> - Razlika pri seštevanju vpliva zvočnega valovanja koherentnih in nekoherentnih zvočnih virov; - Seštevanje frekvenčnih območij v totalno raven; - Vpliv odbojev na meritve v frekvenčnem območju; - Hrup ozadja in uporabno frekvenčno območje meritev; - Formiranje stoječega valovanja, odboj od togega konca cevi in odprtega konca cevi, vpliv nenadne zožitve in širitve na širjenje zvoka po cevi; - Prosto zvočno polje in difuzno zvočno polje. <p>6. Absorpcija zvoka:</p> <ul style="list-style-type: none"> - Mehanizmi absorpcije zvoka; - Meritve absorpcije v odmevnici oziroma v alfa 	<p>over competition, the economic aspect of acoustics.</p> <p>2. Sound sources:</p> <ul style="list-style-type: none"> - Basic physical mechanisms of sound generation in the air (aerodynamic, vibroacoustic, thermal); - The correlation between sound and thermodynamics is demonstrated by the derivation of the propagation velocity of a disturbance across different media; - Longitudinal and transversal wave propagation - Euler's simplified form of the fluid motion equation; - Description of the wave equation for the 1D propagation of sound wave and explanation of its solutions in the space time domain; - Correlation between the time and space in the sound pressure field. <p>3. Sound propagation:</p> <ul style="list-style-type: none"> - Acoustic impedance - correlation between sound pressure and particle motion velocity; - Huygen's description of sound wave deflection, reflection and scattering; - Transition from 1D sound wave $p(x, t)$ to 3D sound wave $p(x, y, z, t)$, into Spherical wave $p(r, t)$; - The importance of the relationship between the wavelength and the propagation space geometry size and/or the size of obstacle in the path of sound ($k=2\pi/\lambda$, k_r, k_x); - Sound pressure as a result of the volume flow through the point sound source; - Near and far field of a spherical sound sources; - Real sound sources and their comparison across size classes. <p>4. Acoustic measuring system:</p> <ul style="list-style-type: none"> - Microphone principles, amplitude response linearity and harmonic distortions, frequency response linearity, directivity; - Microphone calibration to SI units; - Microphone signals, RMS value and influence of integration time constants on measurement results, everyday microphone calibration; - Definition of decibel level and its usefulness to describe the amplitudes of audio signals, equivalent level as a statistical representation of the measured signal stationarity; - Octave and 1/3 octave filters, signal filtering, FIR filter, FFT; - Frequency weighting according to "A", "B" and "C" curves. <p>5. Sound fields:</p> <ul style="list-style-type: none"> - Difference in the summation of sound generated by coherent and incoherent sound sources; - Summation of more levels in different frequency ranges to the total level; - Effect of sound reflections on the measurements,
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<p>komori;</p> <ul style="list-style-type: none"> - Meritve impedančni cevi z metodo razmerja stoječega valovanja in z metodo prenosnih funkcij; - Reaktivni glušniki - Helmholtzov resonator, pasivna membrana, ekspanzijska komora, resonator valovne dolžine četrтин. <p>7. Vibroakustika:</p> <ul style="list-style-type: none"> - Vibroakustični monopol, dipol in kvadropol; - Sevanje zvoka iz majhnega bata, iz velikega bata in iz kompleksne vibrirajoče površine; - Zelo bližnje polje; - Mehanizem generiranja vibracij zaradi debalansa; - Mehanizmi generiranja vibracij zaradi aerodinamične interakcije med fluidom in površino/telesom; - Mehanizem generiranja vibracij zaradi trenja (Stick/slip pojav). <p>8. Aeroakustika:</p> <ul style="list-style-type: none"> - Aeroakustični monopol, dipol, kvadropol; - Generiranje zvoka na oviri v toku zraka; - Izpeljava povezave med tlačno razliko v sistemu in amplitudo zvočnega tlaka; - Strouhalovo število za oceno frekvenčnega območja zvočnega tlaka; - Meritve v aeroakustiki; - Akustične slike aerodinamičnih virov hrupa. <p>9. Hrup radialnih turbinskih strojev:</p> <ul style="list-style-type: none"> - Nastanek hrupa na radialnih strojih; - Rotirajoče tlačno polje okoli radialnega stroja kot kompleksni zvočni vir; - Vpliv jezička na spirali na generiranje zvočnega tlaka; - Hrup zaradi nestabilnega delovanja; - Opis nastanka spektra hrupa radialnega stroja in luščenje informacij o delovanju strojev iz izmerjenih spektrov hrupa; - Zmanjševanje hrupa (zvočne moči) radialnim turbinskim delovnim strojem. <p>10. Hrup aksialnih turbinskih strojev:</p> <ul style="list-style-type: none"> - Nastanek hrupa na aksialnih strojih; - Vpliv reže med vrhom lopatice in obročem na hrup; - Rotirajoče tlačno polje kot kompleksni zvočni vir; - Hrup zaradi nestabilnega delovanja; - Utripanje kot posledica vzporedne vezave aksialnih ventilatorjev. <p>11. Hrup kompleksnih postrojenj:</p> <ul style="list-style-type: none"> - Hrup turbinskih strojev kot funkcija delovne točke; - Spekter hrupa turbinskih strojev; - Afiniteti zakoni turbinskih strojev za akustiko; - Modeli ocene zvočne moči plinskih turbin, parnih turbin, parnih kotlov, batnih kompresorjev, centrifugalnih črpalk. <p>12. Hrup elektromotorjev in transformatorjev:</p> <ul style="list-style-type: none"> - Delovanje različnih elektromotorjev in mehanizmi generiranja hrupa pri elektromotorjih; - Tipični spekter hrupa elektromotorjev; 	<p>demonstrated in the frequency domain;</p> <ul style="list-style-type: none"> - Influence of the background noise spectrum on valid frequency range of measurements; - Formation of standing wave, reflection from the rigid end of the acoustic channel and from the open end of the acoustic channel, the effect of sudden change in acoustic channel cross section on the sound propagation; - Difference between free field and diffuse sound field. <p>6. Sound absorption:</p> <ul style="list-style-type: none"> - Physical mechanisms of sound absorption; - Measurements of absorption in the echo or alpha chamber; - Measurements of absorption in the impedance using the standing wave ratio method and the transfer function method; - Reactive silencers - Helmholtz resonator, passive membrane, expansion chamber, quarter wavelength resonator. <p>7. Vibroacoustics:</p> <ul style="list-style-type: none"> - Vibroacoustic monopole, dipole and quadrupole; - Sound emission from a small piston, a large piston and a complex vibrating surface; - Acoustic Very Near Field; - Mechanisms of the vibration generation due to rotor debalance; - Mechanisms of the vibration generation due to the aerodynamic interaction between the fluid and the rigid surface / body; - Mechanisms of the vibration generation due to instable nonlinear friction mechanism (Stick / Slip phenomenon). <p>8. Aeroacoustics:</p> <ul style="list-style-type: none"> - Aeroacoustic monopole, dipole, quadrupole; - Generation of sound on the obstruction in the air flow; - Derivation of the correlation between the pressure difference on the obstruction in airflow and the amplitude of the sound pressure; - Strouhal number and its use for estimation of noise frequency spectrum; - Measurements in aeroacoustics; - Acoustic images of aeroacoustic noise sources. <p>9. Noise of radial turbo machines:</p> <ul style="list-style-type: none"> - Noise generation on radial machines; - Rotating pressure field around the radial machine as a complex sound source; - The influence of the housing cut off on the generation of noise level; - Noise due to unstable operation; - Description of the noise spectrum generated by the radial turbo machines and extraction of information about the operation of the machines from the measured
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<ul style="list-style-type: none"> - Ocenjevanje zvočne moči elektromotorjev; - Hrup transformatorjev. <p>13. Zmanjševanje hrupa pri viru:</p> <ul style="list-style-type: none"> - Izbira delovnega stroja, procesa, tehnologije... - Načini vgradnje strojev in naprav; - Delovna točka strojev in naprav; - Vibroizolacija. <p>14. Zmanjševanje hrupa na poti širjenja:</p> <ul style="list-style-type: none"> - Izbira, izračun in načrtovaje reaktivnih glušnikov za preprečevanje širjenja hrupa po ceveh in kanalih; - Akustična učinkovitost pregradnih sten, ograj, zaslonov; - Načrtovanje in izračun učinkovitosti akustičnih oklepov; - Zmanjševanje ravni hrupa s skrajševanjem odmevnega časa; - Aktivno dušenje hrupa. <p>15. Zmanjševanje hrupa pri sprejemu:</p> <ul style="list-style-type: none"> - Osebna zaščitna sredstva; - Določanje učinkovitosti zaščitnih sredstev; - Maskiranje hrupa; - Psihoakustika; - Zvočna kvaliteta izdelkov. 	<p>noise spectra;</p> <ul style="list-style-type: none"> - Reduction of noise (sound power), generated by radial turbo machine. <p>10. Axial turbine machine noise:</p> <ul style="list-style-type: none"> - Noise generation on axial machines; - Impact of the gap between the tip of the blade and the ring on noise levels; - Rotating pressure field as a complex sound source; - Noise due to unstable operation; - Noise beating as a result of parallel coupling of more axial fans. <p>11. Noise of complex installations:</p> <ul style="list-style-type: none"> - Noise of turbo machinery as a function of their operating point; - Noise spectrum of turbine machines; - Acoustics affinity laws for turbo machinery; - Sound power rating models for gas turbines, steam turbines, steam boilers, reciprocating compressors, centrifugal pumps. <p>12. Noise of electric motors and transformers:</p> <ul style="list-style-type: none"> - Operation of different electric motors and mechanisms of noise generation in electric motors; - Typical noise spectrum of electric motors; - Evaluation of the sound power of electric motors; - Transformer noise. <p>13. Noise reduction at source:</p> <ul style="list-style-type: none"> - Selection of technology, selection of machinery, process... - Methods of machinery and devices installation, for improved noise control; - Operational point of machines and appliances; - Vibration isolation. <p>14. Noise reduction along the propagation path:</p> <ul style="list-style-type: none"> - Selection, calculation and design of reactive silencers to prevent the propagation of noise through channels and ducts; - Acoustic efficiency of partitions, fences, and screens; - Design and calculation of the effectiveness of acoustic armour; - Reducing noise levels by reducing reverberation time; - Active noise cancellation. <p>15. Noise reduction at the receiver:</p> <ul style="list-style-type: none"> - Personal protective equipment; - Determination of the effectiveness of protective equipment; - Noise masking; - Psychoacoustics; - Sound quality of products.
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A. Belšak, J. Prezelj, Vibracije in Zvok v vzdrževanju, Univerzitetni učbenik Univerze v Mariboru, 2013

G. Müller, M. Möser, Handbook of Engineering Acoustics, Springer Verlag, 2013

M. Möser, S. Zimmermann, R. Ellis, Engineering Acoustics: An Introduction to Noise Control, Springer Verlag, 2004

J. Blauert, N. Xiang, Acoustics for Engineers - Troy Lectures, , Springer Verlag, 2009

Cilji in kompetence:

Cilji:

Spoznati različne mehanizme generiranja zvoka in pridobiti potrebna znanja za njihov matematični opis

Spoznati načine širjenja zvoka po prostoru in razlikovati med različnimi zvočnimi polji z namenom napovedovanja širjenja hrupa v naravno, življenjsko in delovno okolje

Dobiti poglobljeno znanje o delovanju strojev naprav in procesov z namenom zniževanja njihovega hrupa

Spoznati osnovne metode meritev vibroakustičnih veličin z namenom samostojnega izvajanja meritev in zagotavljanja njihove sledljivosti

Kompetence:

S1-PAP: Sposobnost uporabe pridobljenega znanja v praksi.

S11-PAP: Sposobnost predstavitve strokovnih problemov in njihovih rešitev v svojem okolju in širše.

S14-PAP: Poznavanje važnejših strokovnih izrazov v angleškem jeziku

P10-PAP: Sposobnost povezovanja znanj iz več različnih področij (termodinamika, turbinski stroji, elektrotehnika, numerične metode) v novo zaključeno celoto - Hrup strojev, naprav in procesov in njegovo zmanjševanje

Objectives and competences:

Objectives:

To learn different basic mechanisms of sound generation and to attain the necessary knowledge for their mathematical description

To understand mechanisms of sound propagation through air and to distinguish between different types of sound fields in order to predict the propagation of noise into the natural, living and working environment

Gain an in-depth knowledge of the operation of machines, devices and processes, from acoustical stand point of view, with the purpose to design acoustically optimized products

To acquire the basic skills of measuring vibroacoustic quantities in order to perform measurements independently and to ensure the traceability of results

Competences:

S1-PAP: The ability to use the attained knowledge in the practice.

S11-PAP: The ability to present professional problems and the solutions thereof in own environment and wider.

S14-PAP: Learning the indispensable technical vocabulary in English or German language

P10-PAP: Ability to integrate knowledge from several different fields (thermodynamics, turbo machinery, electrical engineering, numerical methods) into a newly completed unit - Noise control of machines, devices and processes.

Predvideni študijski rezultati:

Znanja:

Poglobljeno strokovno teoretično in praktično znanje s področja akustike, podprto s širšo teoretično in metodološko osnovo, ki posamezniku omogoča začetek samostojnega dela na področju zmanjševanja hrupa strojev naprav in procesov na osnovi:

znanje o mehanizmi generiranja zvoka in njihovem matematičnem opisu,

Intended learning outcomes:

Knowledge:

In-depth professional theoretical and practical knowledge in the field of acoustics, supported by a broader theoretical and methodological basis, which enables an individual to start independent work in the field of noise reduction of machine devices and processes on the basis of:

knowledge of the mechanisms of sound generation and

<p>znanju o načinih širjenja zvoka po prostoru in o različnih zvočnih poljih,</p> <p>znanja o napovedovanju širjenja hrupa v naravno, življenjsko in delovno okolje,</p> <p>znanje o delovanju strojev naprav in procesov kot virov hrupa,</p> <p>znanja osnovnih metod meritev vibroakustičnih veličin z namenom samostojnega izvajanja meritev</p> <p>Spretnosti:</p> <p>S1.1: Izvajanje kompleksnih operativno-strokovnih opravil, ki vključujejo tudi uporabo metodoloških orodij, ki temeljijo na iskanju povezave med eksperimentalnimi rezultati meritev vibroakustičnih veličin in teoretičnimi osnovami.</p> <p>S1.2: Obvladovanje zahtevnih, kompleksnih delovnih procesov ob samostojni uporabi znanja v novih delovnih situacijah.</p> <p>S1.3: Diagnosticiranje in reševanje problemov v različnih specifičnih delovnih okoljih.</p>	<p>their mathematical description,</p> <p>knowledge of the ways in which sound is propagated through space and of different sound fields,</p> <p>knowledge of predicting the spread of noise into the natural, living and working environments,</p> <p>knowledge of the operation of machinery of devices and processes as sources of noise,</p> <p>knowledge of basic methods of vibroacoustic measurements for the purpose of independent measurement</p> <p>Qualifications</p> <p>S1.1: Performing complex operational and professional tasks, including the use of methodological tools based on the search for a correlation between the vibroacoustic experimental results and the theoretical background</p> <p>S1.2: Coping with complex, multi-layered work processes with the independent application of knowledge in new work situations.</p> <p>S1.3: Diagnosis and problem solving in various specific work environments.</p>
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Metode poučevanja in učenja:	Learning and teaching methods:
<p>P1: Avditorna predavanja z reševanjem izbranih teoretičnih in praktično uporabnih primerov.</p> <p>P2: Obravnava snovi po urejeni in vnaprej razloženi sistematiki.</p> <p>P4: Laboratorijske vaje z namenski didaktični pripomočki:</p> <p>Impedančna cev za prikaz stoječega zvočnega polja in za razlago povezave med zvočnim tlakom in hitrostjo delcev.</p> <p>Gluha soba za prikaz prostega zvočnega polja in kot orodje za izvajanje meritev.</p> <p>Alfa komora (mala odmevnica) kot standardiziran prostor za simulacije zvočnih polj realnih virov hrupa.</p> <p>Mikrofonska antena s 16 kanalnim AD pretvornikom za prikaz širjenja valovanja in opis metod izdelave akustičnih slik.</p> <p>Uparjena mikrofona kot osnova za meritve zvočne intenzivnosti.</p> <p>Merilniki hrupa kot osnovno orodje za merjenje ravni in spektrov hrupa.</p> <p>Aeroakustični kanal za prikaz nastanka aerodinamičnega hrupa in metodologija kvantifikacije</p>	<p>P1: Classroom lectures by solving selected theoretical and practical examples.</p> <p>P2: Discussions on the topics predefined in of the curriculum according to an orderly and pre-interpreted systematics.</p> <p>P4: Laboratory exercises with dedicated teaching aids:</p> <p>An impedance tube for demonstrating a standing sound field, for explaining the relationship between the sound pressure and the particle velocity and for measuring the speed of sound.</p> <p>Anechoic chamber to display free sound field and as a tool to perform measurements.</p> <p>Alpha chamber (small echo) as a standardized space for simulation of sound fields of real noise sources.</p> <p>Microphone array with 16 channel AD converter for demonstrating wave propagation and describing methods for producing acoustic images.</p> <p>Paired microphones for sound intensity measurements.</p> <p>Noise Level Meters as a basic tool for measuring noise levels and spectra.</p> <p>Aeroacoustic flow channel for demonstration of aerodynamic noise generation and explanation of</p>

<p>aeroakustičnega monopola, dipola in kvadropola.</p> <p>Osebni računalniki z naloženo programsko opremo i-noise za modeliranje širjenja hrupa po naravnem in življenjskem okolju.</p> <p>Merilni sistem za Adriane Metodo namenjen prikazu impulznih odzivov in določanju koeficienta absorpcije večjim panelom.</p> <p>Umirjevalna komora za merjenje zvočne moči radialnim puhalom, za prikaz vpliva delovne točke na emitiran hrup puhal in meritve zvočne moči.</p> <p>Cev z zvočno trobljo za merjenje zvočne moči aksialnih ventilatorjev, za prikaz vpliva delovne točke na emitiran hrup aksialnega ventilatorja in meritve zvočne moči.</p> <p>Sistem za kavitacijo na radialni črpalki, za predstavitev uporabnosti zvoka za monitoring delovanja strojev in naprav.</p> <p>Referenčni omnidirekcionalni zvočni vir in kalibriran vir udarnega hrupa, za praktično izvajanje merjenj zvočne izolativnosti v gradbeni akustiki.</p> <p>Ultrazvočni pretočni kanal z opazovalnim oknom, za prikaz delovanja ultrazvoka in vpliva kavitacije na erozijo površine.</p> <p>P5: Uporaba študijskega gradiva v obliki:</p> <p>Skripta predavanj</p> <p>interaktivne PPT prosojnice.</p> <p>Predloge za pripravo na vsako vajo posebej.</p> <p>Navajanje aktualnih povezav na javno dostopna predavanja iz tematik akustike.</p> <p>P7: Študij literature in razprava</p> <p>P8: Izdelava in predstavitev aplikativnih seminarских nalog</p> <p>P10: Uporaba anket v realnem času</p> <p>P14: Virtualni eksperimenti</p> <p>P15: Uporaba video vsebin kot priprava na predavanja in vaje</p>	<p>quantification methodology for aeroacoustic monopole, dipole and quadrupole.</p> <p>Personal Computers with installed i-Noise application for modelling the propagation of noise through the natural and living environment.</p> <p>Adriane Method measuring system for demonstration and measurements of impulse responses and to determine the absorption coefficient for larger panels.</p> <p>Stabilization chamber for measuring acoustic power by radial blowers, for indicating the effect of the operating point on the emitted noise of the blower and for measuring acoustic power.</p> <p>Anechoic duct with a large horn for measuring the sound power of axial fans and for demonstrating the effect of the operating point on the emitted noise of the axial fan</p> <p>Radial pump cavitation system for demonstrating the usefulness of sound for monitoring the operation of machines and devices.</p> <p>Reference omnidirectional sound source and calibrated impact noise source for practical measurement of sound insulation in building acoustics.</p> <p>Ultrasonic flow channel with an observation window to show the operation of ultrasound and the effect of cavitation on the surface erosion.</p> <p>P5: Use of specifically prepared literature in the form of:</p> <p>Lecture Script available online</p> <p>Interactive PPT slides.</p> <p>Templates for preparation to each individual laboratory exercise</p> <p>Internet links of publicly available acoustics lectures from other universities.</p> <p>P7: Study of selected literature and its discussion</p> <p>P8: Preparation of the presentations of practical experimental work in the laboratory</p> <p>P10: Use real-time surveys</p> <p>P14: Virtual Experiments</p> <p>P15: Using video content to prepare for lectures and tutorials</p>
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Načini ocenjevanja:	Delež/Weight	Assessment:
- Teoretične vsebine	40,00 %	- Theoretical content
- Samostojno delo na vajah	20,00 %	- Independent work at laboratory exercises
Poročanje rezultatov meritev iz vaj	20,00 %	Reporting on experiments

Seminar z vsebinami iz vaj	20,00 %	Seminar with content from laboratory exercises

Reference nosilca/Lecturer's references:

Jurij Prezelj:

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