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Strengthening Educational Capacities by Building Competences and Cooperation in the Field of Noise and Vibration Engineering
S E N V I B E

Report on Redesign of Existing Courses

Activity 3.1

Date: 12/12/2020

Content:

1. Introduction

The project SENVIBE 'Strengthening Educational Capacities by Building Competences and Cooperation in the Field of Noise and Vibration (No&Vib) Engineering' (598241-EPP-1-2018-1-RS-EPPKA2-CBHE-JP):

https://senvibe.uns.ac.rs/

has been approved for financing under the call Erasmus+ Capacity Building in Higher Education EAC/A05/2017, and will be coordinated by University of Novi Sad (UNS) during the period 15 November 2018 – 14 November 2021.

The wider aim of the SENVIBE project is to improve national educational capacities, cooperation and competences in dealing with environmental and occupational Noise and Vibration (No&Vib) engineering issues. One of the specific objectives is to update the existing courses or design new ones in the field of No&Vib for students of undergraduate programmes of six different engineering departments: Occupational Safety, Environmental, Mechanical, Electrical, Civil and Traffic Engineering. These activities are incorporated into the SENVIBE Work Package 3 (WP3) Development of Modules and Courses for Different Engineering Departments, and they follow up the SENVIBE preparation phase, and in particular the SENVIBE Task 1.2 Define Tailor-Made Learning Outcomes for Students of Six Engineering Departments. The Report for this Task 1.2[1] pointed out that besides special courses on No&Vib, there are also other courses, such as courses on Physics, whose modules are seen as appropriate for educating a larger pool of engineers-to-be on No&Vib. They are usually given to freshers, covering a significantly larger number of students than courses on No&Vib, which are taught at later years. Therefore, the current Report for the SENVIBE Task 3.1 includes both the courses on No&Vib (Section 2) and short modules on No&Vib taught in courses of Physics (Section 3). When considered jointly with the Report on New Courses[2], this Report gives certain overview of the education on No&Vib at four Serbian universities from the SENVIBE consortium: University of Novi Sad (UNS), University of Nis (UNI), University of Kragujevac (UniKG) and Educons University from Sremska Kamenica (EUSK) at their respective faculties (one per each): Faculty of Technical Sciences in Novi Sad, Faculty of Occupational Safety in Nis, Faculty of Mechanical and Civil Engineering in Kraljevo and Faculty of Environmental Protection in Sremska Kamenica. These courses and modules have a variety of new learning and teaching material at their disposal, as well as new lab facilities. This new learning and teaching material designed during the SENVIBE project has been uploaded to a new ICT platform 'e-SENVIBE'[3], specially created for this purpose.

This Report, in a similar way as the Report on New Courses[2], appears with a certain delay with respect to the date planned in the SENVIBE proposal. This delay is caused by a slow accreditation process of several study programmes in which some of

1 https://senvibe.uns.ac.rs/wp-content/uploads/2019/04/SENVIBE_Report_Task1.2_version24April2019.pdf, assessed 29 Nov 2020.
2 https://senvibe.uns.ac.rs/2020/11/29/design-of-new-courses-24-november-2020/, assessed 29 Nov 2020.
3 https://senvibe.uns.ac.rs/2020/11/07/requirements-design-and-enhancement-of-an-ict-platform-7-november-2020/, assessed 29 Nov 2020.

the courses are included. However, this delay was due to the external factor mainly caused by COVID-19, which was beyond the control of the project partners.

2. Existing Courses on Noise and Vibration

This section provides details about the courses on No&Vib, which existed before and have been updated, and are newly accredited or recognised during 2020 at four faculties from four universities listed in the Introduction. They are given in different tables depending on the study programme to which they belong.

REMARK 1: It is assumed that each course is taught during a semester that lasts 15 weeks.
REMARK 2: The subsequent tables contain educational goals and outcomes, teaching methods, notes on the course content and appropriate teaching/learning methodologies and comments. To validate the existence of courses, the links to the institutional pages where the corresponding study programmes, current and previous courses appear, are provided.

2.1 Occupational Safety Engineering

Table 2.1.1 Course 'Noise and Vibration' at UNI

University	University of Nis
Faculty	Faculty of Occupational Safety
Study programme	Occupational Safety Engineering https://www.znrfak.ni.ac.rs/SERBIAN/001-02-03-AkreditacijaOAS.html
Course title	Noise and Vibration (*recognised*) https://www.znrfak.ni.ac.rs/SERBIAN/002-SISTEM-KVALITETA/AKREDITACIJA%202020/OAS-ZNR/Knjiga_predmeta_OAS_ZNR.pdf https://www.znrfak.ni.ac.rs/SERBIAN/010-STUDIJE/OAS-4-1/III%20GODINA/PREDMETI/ZNR-302-BUKA%20I%20VIBRACIJE/DINAMICKI%20PLAN/2020-21/Specifikacija%20predmeta%202020-2021.pdf
ECTS	6
Educational goals	• To equip students with the knowledge, understanding, and application of noise and vibration principles and phenomena that underpin prudent use of the corresponding theoretical framework, computer software, and experimental techniques. • To enable students to comprehend knowledge of human responses to noise and vibration in a working environment and their effects on a human body, as well as to integrate this knowledge into relevant practical applications in the field of Occupational Safety Engineering.
Educational outcomes	By the end of the course, students should be able to: • identify and examine real noise and vibration issues; • recognize noise and vibration sources and phenomena and evaluate them through measurements; • suggest measures to solve noise and vibration problems;

	• understand the human responses to whole-body vibration, hand-arm vibration, as well as human responses to occupational noise; • recognize and select appropriate standards, recommendations, or regulations that apply to a working environment. Identify practical measures for human protection and their implementation.
Course structure and content	Theoretical teaching **The physical concept of sound:** Sound generation. Application of sound. Definitions of sound and noise. Sound propagation. Types of sound waves. Sound wave quantities. Phenomenon occurring in the propagation of sound waves. **Acoustic energy quantities**: Sound energy. Density of sound energy. Sound Intensity. Sound power. **Point sound sources:** Model of sound point sources. Sound sources with omnidirectional and directional radiation. Spatial angle of sound radiation. The combined effect of independent sound sources (simple and complex sound). Sound source next to the obstacle. **Sound perception:** Definition of sound perception. Hearing organ - outer, middle and inner ear. Sound transmission. Sound energy distribution at the basilar membrane. Frequency range of audible sound. Dynamic range of audible sound. **Objective quantities for describing sound**: Reason for using sound levels. Definition of sound level. Sound level scale. Change of the sound level. The resulting level of complex sound. Sound level of a specific sound source. **Subjective quantities for describing sound:** Sound loudness level. Sound loudness. **Weighting frequency curves:** A and C curve. **Subjective energy quantities:** Equivalent sound level. Sound exposure level. **Indoor acoustics:** Mathematical models of sound field. Sound energy absorption coefficient. Statistical theory of sound field. Reverberation time. Rooms with a high sound absorption coefficient. **Sound insulation:** Phenomena occurring when sound wave encounters a barrier. Transmission loss coefficient. Sound reduction index of a barrier. Sound insulation of a room. **Noise Types:** Noise characteristics. Types of noise in relation to the time domain character of noise. Types of noise in relation to the frequency domain character of noise. Noise types in relation to the type of noise sources. **Noise measurement instruments and measuring quantities:** Structure of noise measurement instruments. Condenser microphone. Bandwidth and narrowband frequency analysis of noise signals. Noise signal detector. Measurement quantities. **Measurement of occupational noise:** Sources of the noise in the work environment. Quantities for estimating noise exposure. Standards and regulations for measuring occupational noise. Methodology for measuring and calculating

	quantitates for the assessment of noise exposure. Allowed noise levels in the work environment. **The effect of noise on human health:** Auditory effect of noise. Extra-auditory noise effect. Personal protective equipment for noise protection. **Physical concept of vibration:** Definition of vibration. Vibration sources. Mechanical system components. Forces that occur during vibration. Vibration generation. Vibration classes. Basic vibration quantities. Vibration level. Basic vibration signal descriptors. Types of vibration. Motion degrees of freedom. Harmonic and non-harmonic vibrations. Composition of collinear synchronous and asynchronous vibrations. **Assessment of human vibrations transmitted to the human body during operation:** Human body and vibration. Transmission of vibrations to the human body. Assessment of vibrations transmitted to the human body. **Vibration measurement instruments and measuring quantities:** Structure of vibration measuring instruments for human vibrations. Accelerometers - principle of operation and installation. Frequency weighting curves. Measuring quantities. **Measurement and effects of vibration transmitted to the human body during operation:** Standards and regulations for measuring vibration in the work environment. The process of measuring vibrations transmitted to the human body. **Effects of vibration on the human body - vibrational diseases:** Personal protective equipment for vibration protection. Practical classes - computational and laboratory exercises Computational and laboratory exercises are thematically followed by theoretical instructions and contribute to a better understanding of the material and enrich knowledge. Computational exercises: • Calculation of values of different acoustic quantities under specific conditions of operation of the noise source: sound pressure, sound power, intensity, sound level, sound loudness level, sound loudness, equivalent sound level, sound exposure level, sound absorption coefficient, equivalent absorption area of room, reverberation time of rooms, sound insulation of the room; • Composition of collinear synchronous and asynchronous vibrations; • Calculation of daily vibration exposure values for cases of vibration transmissions to the worker through the hand-arm and whole-body system, as well as estimation of the state of vibration exposure in relation to the prescribed action and limit values. Laboratory exercises: 1. Sound power measurements of a noise source; 2. Calculation of a daily noise exposure level of workers based on the results obtained from measured noise levels; 3. Measurement of reverberation time and sound insulation of the room;

	4. Calculation of daily vibration exposure of workers based on the results of acceleration measurement during handling hand tools and operating vehicles.
Teaching methods	Lectures; Tutorial classes; Laboratory classes; Assignments.
Literature	1. D. Cvetković, M. Praščević, Noise and Vibration, Faculty of Occupational Safety, University of Nis, Nis, 2005 (In Serbian). 2. D. Cvetković, M. Praščević, Noise and Vibration – Collection of Exercises with Theoretical Background, Publishing Unit of the University of Niš, 1999 (In Serbian). 3. D. Cvetković, M. Praščević, D. Mihajlov, Physical Hazards – Collection of the Solved Exercises, Faculty of Occupational Safety in Nis, 2013 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modeling assumptions in the light of experimental data.
Previous course	Noise and Vibration https://www.znrfak.ni.ac.rs/SERBIAN/002-SISTEM-KVALITETA/AKREDITACIJA%202014/OAS%20ZNR/Knjiga%20predmeta/OAS%20-%20Knjiga%20predmeta%20-%20ZNR.pdf https://www.znrfak.ni.ac.rs/SERBIAN/010-STUDIJE/OAS-4-1/III%20GODINA/PREDMETI/ZNR-302-BUKA%20I%20VIBRACIJE/DINAMICKI%20PLAN/2019-20/Specifikacija%20%20predmeta%20Buka%20i%20vibracije.pdf

Table 2.1.2 Course 'Occupational Noise and Vibration' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Occupational Safety Engineering http://www.ftn.uns.ac.rs/462098969/inzenjerstvo-zastite-na-radu
Course title	Occupational Noise and Vibration (*accredited*) http://www.ftn.uns.ac.rs/1628443632/buka-i-vibracije-u-radnoj-sredini
ECTS	4
Educational goals	• To equip students with the knowledge and understanding of noise and vibration phenomena from the engineering point of view, with the aim of defining them mathematically, determining the cause of their generation, the consequences

	that affect occupational safety, as well as their identification, measurement and mitigation.
Educational outcomes	By the end of the course, students should be able to: • create a detailed overview of noise and vibration phenomena in the working environment, • recognize and determine their causes; • remove or control undesirable consequences. • acquire competences for choosing the right equipment for human protection in the working environment.
Course structure and content	The concept of sound and noise. Sound intensity and sound pressure. Sound pressure level. Sound power and noise source characteristics. Physiological acoustics. Acoustic characteristics of an enclosed space. Absorption characteristics. Reverberation time. Room size, shape and design as acoustic parameters. Noise reduction. Occupational noise legislation. Identification of noise sources. Sound field calculations (mathematical models). Examples on industrial plants. Criteria for evaluating protective solutions. Transmissibility. Vibration isolation. Active protection. Passive protection methods. Equipment for noise and vibration protection.
Teaching methods	Lectures; Tutorial classes; Laboratory classes; Consultations; Continuous monitoring of students' level of knowledge through tests and exams.
Literature	1. D. Cvetković, M. Praščević, Noise and Vibration, Faculty of Occupational Safety, University of Nis, Nis, 2005 (In Serbian). 2. J. Den Hartog, Mechanical Vibrations, Civil Engineering Book, Belgrade, 1972 (In Serbian). 3. I. Kovacic, D. Radomirovic, Mechanical Vibrations, John Wiley&Sons, 2017. 4. W. Brazile, Occupational & Community Noise: A Guide for Environmental Health & Safety Students, Kendall Hunt, 2017.
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modeling assumptions in the light of experimental data.
Previous course	Protection from Noise and Vibration in Industry http://www.ftn.uns.ac.rs/1510063319/zastita-na-radu-od-buke-i-vibracija-u-industriji

2.2 Environmental Engineering

Table 2.2.1. Course 'Noise and Vibration' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Environmental Engineering http://www.ftn.uns.ac.rs/n1521933703/inzenjerstvo-zastite-zivotne-sredine
Course title	Noise and Vibration (*accredited*) http://www.ftn.uns.ac.rs/351744437
ECTS	4
Educational goals	• To equip students with the knowledge and understanding of noise and vibration phenomena from the engineering point of view, with the aim of defining them mathematically, determining the cause of their generation, the consequences that affect occupational safety and environment, as well as their identification, measurement and mitigation.
Educational outcomes	By the end of the course, students should be able to: • create a detailed overview of noise and vibration phenomena in the working environment, • recognize and determine their causes; • remove or control undesirable consequences.
Course structure and content	The concept of sound and noise. Sound waves propagation. Plane waves. Spherical waves. Sound intensity and sound pressure. Sound pressure level. Acoustic impedance. Sound power and noise source characteristics. Sound diffraction and reflection. Acoustic characteristics of an enclosed space. Absorption characteristic. Reverberation time. Room size, shape and design as acoustic parameters. Noise reduction. Transmissibility. Vibration isolation. Technical measures for protection against noise and vibration. Active methods of protection. Passive protection methods. Identification of noise sources. Sound field calculation of industrial plants. Criteria for evaluating protectivee solutions. Equipment for noise and vibration protection.
Teaching methods	Lectures; Tutorial classes; Laboratory classes; Consultations; Continuous monitoring of students' level of knowledge through tests and exams.
Literature	1. D. Cvetković, M. Praščević, Noise and Vibration Faculty of Occupational Safety, University of Nis, Nis, 2005. (In Serbian). 2. J. Den Hartog, Mechanical Vibrations, Civil Engineering Book, Belgrade, 1972 (In Serbian). 3. I. Kovacic, D. Radomirovic, Mechanical Vibrations, John Wiley&Sons, 2017.
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.

Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modeling assumptions in the light of experimental data.
Previous course	Noise and Vibration http://www.ftn.uns.ac.rs/n956830477/buka-i-vibracije

2.3 Mechanical Engineering

Table 2.3.1 Course 'Vibration, Noise and Design' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Mechanical Engineering – Technical Mechanics http://www.ftn.uns.ac.rs/n1626924295/tehnicka-mehanika-i-dizajn-u-tehnici
Course title	Vibration, Noise and Design (*accredited*) http://www.ftn.uns.ac.rs/1498608453/vibracije--buka-i-dizajn
ECTS	6
Educational goals	• To equip students with the knowledge and understanding of noise and vibration phenomena from the engineering point of view, with the aim of defining them mathematically, determining the cause of their generation, the consequences that affect occupational safety and environment, as well as their identification, measurement and mitigation.
Educational outcomes	By the end of the course, students should be able to: • create a detailed overview of noise and vibration phenomena in the working environment; • recognize and determine their causes; • remove or control undesirable consequences.
Course structure and content	The concept of sound and noise. Sound waves propagation. Plane waves. Spherical waves. Sound intensity and sound pressure. Sound pressure level. Acoustic impedance. Sound power and noise source characteristics. Sound diffraction and reflection. Acoustic characteristics of an enclosed space. Absorption characteristic. Reverberation time. Room size, shape and design as acoustic parameters. Noise reduction. Transmissibility. Vibration isolation. Technical measures for protection against noise and vibration. Active protection methods. Passive protection methods. Identification of noise sources.
Teaching methods	Computational exercises; Consultations; Continuous monitoring of knowledge levels through tests; Exam.
Literature	1. D. Cvetković, M. Praščević, Noise and Vibration Faculty of Occupational Safety, University of Nis, Nis, 2005 (In Serbian).

	2. H. Kurtovic, Fundamentals of Technical Acoustics, Science Book, Belgrade, 1977. 3. J. Den Hartog, Mechanical Vibrations, Civil Engineering Book, Belgrade, 1972 (In Serbian). 4. G. Erdeljani, P. Pravica, Solved Examples in Technical Acoustics, Faculty of Technical Sciences, Novi Sad, 1991.
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modelling assumptions in the light of experimental data.
Previous course	Noise, Vibration and Design http://www.ftn.uns.ac.rs/1902512611/buka--vibracije-i-dizajn

Table 2.3.2 Course 'Theory of Oscillations' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Mechanical Engineering – Technical Mechanics http://www.ftn.uns.ac.rs/n1626924295/tehnicka-mehanika-i-dizajn-u-tehnici Mechanical Engineering – Mechanisation and Constructive engineering http://www.ftn.uns.ac.rs/1926303673/mehanizacija-i-konstrukciono-masinstvo
Course title	Theory of Oscillations (*accredited*) http://www.ftn.uns.ac.rs/n1857547915/teorija-oscilacija
ECTS	5
Educational goals	• To acquiring basic knowledge from the theory of oscillations and phenomena of oscillatory motion.
Educational outcomes	By the end of the course, students should: • acquire the knowledge necessary for a contemporary mechanical engineer.
Course structure and content	Linear and nonlinear spring. Free oscillations with one degree of freedom of motion. Equivalent stiffness. Kinetic and potential energy of a system with one degree of freedom of motion. Lagrange's equation of motion of the system with one degree of freedom of motion. Raley's process of determining circular frequency. Free oscillations with viscous friction and dry friction oscillations of a system with one degree of freedom of motion. Forced oscillations under the influence of Dirac and Heaviside force. Kinetic and potential energy of a system with two degrees of freedom of motion. Lagrange's equation of motion of the two-

	degree system. Integration of the equation of motion of the system with two degrees of freedom of movement. Forced oscillations of the system with two degrees of freedom of motion. Resonance. Dynamic absorber. The impact of viscous friction on small oscillations of the system with two degrees of freedom of motion. Definition of stability of motion. Longitudinal oscillations of beams. Torsional oscillations. Transversal oscillations. Critical oscillation speeds of elastic shafts. Laval's paradox.
Teaching methods	Lecturing and exercises.
Literature	1. B. Vujanovic, Theory of Oscillations, Faculty of Technical Sciences, Novi Sad, 1995 (In Serbian). 2. I. V. Meschersky, Collection of Examples in Mechanics, Science Book, Belgrade, 1995 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modelling assumptions in the light of experimental data.
Previous course	Theory of Oscillations http://www.ftn.uns.ac.rs/1534991056/teorija-oscilacija

Table 2.3.3. Course 'Noise and Vibration Protection' at UniKG

University	University of Kragujevac
Faculty	Faculty of Mechanical and Civil Engineering in Kraljevo
Study programme	Mechanical Engineering http://www.mfkv.kg.ac.rs/documents/knjiga-predmeta/Knjiga-predmeta_OAS-MI-2020.pdf
Course title	Noise and Vibration Protection (*accredited*) http://www.mfkv.kg.ac.rs/documents/knjiga-predmeta/Knjiga-predmeta_OAS-MI-2020.pdf
ECTS	6
Educational goals	Developing students' knowledge about design of modern systems for noise and vibration protection. Formation of an ecological position about the impact of industrial and traffic noise on the quality of life.
Educational outcomes	A broad knowledge necessary for understanding of existing engineering solutions in the field of environmental protection. Develops the ability to identify and examine real noise and vibration issues, recognize noise and vibration sources and phenomena and evaluate them through measurements, and in particular to identify and investigate noise and vibration problems that arise in the work of mechanical engineers, then to suggest

	measures to solve noise and vibration problems, recognize and select appropriate standards, recommendations, or regulations that apply to industrial environments, and finally the ability to design a noise protection system using the methodology taught in the course itself and in some of the previous courses. The student will also develop the ability to work in multidisciplinary teams.
Course structure and content	45 classes of lectures + 15 classes of exercises in classroom + 15 classes of exercises in laboratory and industry Theoretical concepts Physical and physiological concepts of noise, noise measurements, indoor noise, utility noise, models for noise forecasting, noise assessment and noise control. Absorption materials for noise protection. Methods for determining the sound absorption coefficient. Acoustic treatment of rooms. Calculation of sound barriers. Porous absorbers, mechanical absorbers, acoustic resonators. Practical work Students in the laboratory or in the field perform measurements of sound pressure, sound intensity, reverberation time, insulating power of all types of barriers. Calculation of sound power level of a source based on measurement of sound pressure level and sound intensity level. Broadband noise measurement and analysis, time and frequency domain noise analysis. Measurement of vibrations of the surfaces of rigid bodies representing the source of sound. In collaboration with the teacher and teaching assistant, the students work on a team project, thematically related to noise protection.
Teaching methods	Theoretical lectures; Practical examples; Laboratory classes; Project assignment.
Literature	1. M. Praščević, D. Cvetković, Environmental Noise, Faculty of Occupational Safety, University of Nis, Nis, 2005 (In Serbian). 2. R. Uzunović, Noise and Vibration Protection, Lola Institute, Belgrade, 1997 (In Serbian)..D. Todorovic, I. Salom , Acoustics – A Collection of Solved Problems, Akademska misao, Belgrade, 2006 (In Serbian). 3. M.J. Crocker, Handbook of Noise and Vibration Control, John Wiley & Sons, Inc., 2007.
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below. Laboratory and practical work is performed at the Laboratory for Acoustics and Technical Diagnostics.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes;

	• question the validity of modelling assumptions in the light of experimental data.
Previous course	Noise Protection http://www.mfkv.kg.ac.rs/index.php/studije/oas-masinsko-inzenjerstvo-2014

Table 2.3.4 Course 'Maintenance and Diagnostics' at UniKG

University	University of Kragujevac
Faculty	Faculty of Mechanical and Civil Engineering in Kraljevo
Study programme	Mechanical Engineering http://www.mfkv.kg.ac.rs/documents/knjiga-predmeta/Knjiga-predmeta_OAS-MI-2020.pdf
Course title	Maintenance and Diagnostics (*accredited*) http://www.mfkv.kg.ac.rs/documents/knjiga-predmeta/Knjiga-predmeta_OAS-MI-2020.pdf
ECTS	6
Educational goals	Introduction of students to concepts and importance of maintenance, which is integral part of all manufacturing activities. Analysis of application of modern methods of technical diagnostics in practical examples and with the practical work of students.
Educational outcomes	The students are able to identify, formulate and solve the engineering problems of maintenance and diagnostics. Besides, they developed the ability to use the basic equipment for technical diagnostics, and particularly to understand the principal responses of mechanical systems to vibration and correlation between mechanical excitations and noise emission of mechanical systems.
Course structure and content	45 classes of lectures + 15 classes of exercises in classroom + 15 classes of exercises in laboratory and industry Theoretical concepts: Maintenance standards and regulations. Phases in the life cycle of technical systems. Maintenance tendencies considering maintenance concepts, policies and maintenance strategies. Maintenance models and application analysis. Defining parameters for monitoring the quality of maintenance and condition of the equipment. Diagnostic methods, devices and their specific application. Maintenance technology, organization, information systems, planning and effectiveness of the maintenance process. Practical work The students practice with the help of the teacher by solving examples that illustrate the concepts taught during the lectures, and at home they do the assignments similar to those used for the exams. Diagnostic measurements of vibration, sound pressure, sound intensity and temperature are being made in laboratories

	and industry. Geometric accuracy is checked in industrial conditions and reports with assessment of the state are made. The project assignment is made in groups or individually, and they comprise solving of a specific maintenance problem (failure tree, failure criticality analysis, plant modernization, etc.).
Teaching methods	Theoretical lectures; Practical examples; Laboratory classes; Project assignment.
Literature	1. G. Ivanović et al, Reliability of Technical Systems, University of Novi Sad, 2010 (In Serbian). 2. Z. Petrović, B. Radičević, Maintenance and Diagnostics – Exercises, Faculty of Mechanical Engineering in Kraljevo, Kraljevo, 2009 (In Serbian). 3. B. Jeremić et al, Technical Diagnostics, Faculty of Mechanical Engineering of University of Kragujevac, 2006 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below. Laboratory and practical work is performed at the Laboratory for Acoustics and Technical Diagnostics.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modelling assumptions in the light of experimental data.
Previous course	Maintenance and Diagnostics http://www.mfkv.kg.ac.rs/index.php/studije/oas-masinsko-inzenjerstvo-2014

2.4 Electrical Engineering

Table 2.4.1 Course 'Monitoring and Noise Protection' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Power, Electronic and Telecommunication Engineering: Information and Communication Technologies and Signal Processing http://www.ftn.uns.ac.rs/n1203679111/informaciono-komunikacione-tehnologije-i-obrada-signala
Course title	Monitoring and Noise Protection (*accredited*) http://www.ftn.uns.ac.rs/1347264554/monitoring-i-zastita-od-buke
ECTS	5

Educational goals	• Noise is becoming an increasing problem in the living and working environment, and more attention is paid to monitoring and protecting against noise. To describe the characteristics of noise and how noise affects people. To explain how to measure noise in both working and living environments. To present measurement devices and tools for noise analysis. To study the standards and regulations on permitted noise level and introduce techniques of measurement, monitoring, and noise protection in both working and living environments.
Educational outcomes	• Students will acquire basic knowledge about noise and its characteristics and impact on people; • They will learn about the standards and regulations on permissible noise levels in both working and living environments; • At exercises they gain practical experience with measurement devices and techniques of measurement, monitoring and noise protection; • Students will learn to measure noise, room acoustic parameters, and insulation power of barriers; • They will be able to identify and qualify potential problems with noise and suggest solutions for the control and noise protection both indoors and outdoors.
Course structure and content	•Audible range and limit of the risk of damage to hearing (ear sensitivity, phone and dB(A)). •Basic characteristics of the noise and its impact on humans (level, spectrum and temporal character). •The noise from multiple sources (equivalent and authoritative level, overall, specific and background noise). •The standards and regulations on permissible noise level in the working and living environments (dB(A) and the normative line of acceptable noise (N-curves) in some areas, the impact of noise on certain activities, permitted noise dose during working hours). •Measuring chain and equipment for measurement and analysis of noise (sound level meters, filters, dosimeters, software tools). •Environmental noise (traffic, construction and communal noise; sources and routes of noise transmission; methods of measuring and noise protection). •Noise in the workplace (acoustic power, methods of measuring noise in the working environment, control measures and the protection of workers). •Monitoring of noise (noise maps in the environment, planning - architectural acoustics). •Noise control (prevention at source (technical and legal means), control of the transmission lines, protection of the receipt).

	•Building acoustics (principles of building vs. principles of acoustics; insulation material power, roads of penetrating noise, structural noise). •Sound insulation (materials and structures, measurement of sound insulation of wall, floor and ceiling, measuring the sound insulation of windows and doors, evaluation of sound insulation in accordance with the regulations and standards, methods to improve the sound insulation). •Methods of prevention and protection from noise (acoustic barriers, sound absorbers, acoustic treatment of rooms and noise insulation, personal protection, active noise canceling).
Teaching methods	Lectures are performed with PowerPoint presentations accompanied by numerous audio and video attachments and animations. They are followed by auditory and laboratory exercises in the Laboratory of Acoustics and Speech Technologies at FTS. Visits to several companies are arranged (and students internship by agreement), where students will learn about the measurement devices, software for noise analysis, and the techniques of measurement, monitoring and noise protection.
Literature	1. D. Cvetković, M. Praščević, Noise and Vibration Faculty of Occupational Safety, University of Nis, Nis, 2005 (In Serbian). 2. D. Drincic, Fundamntals of Acoustics, VSERSS, Belgrade, 2018 (In Serbian). 3. V. Delic, Audio Form of Books and Presentations in CABUNS, University of Novi Sad, 2018 (In Serbian). 4. D. Drincic, P. Pravica, Acoustics – Collection of Solved Examples, VSERSS, Belgrade, 2011 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modeling assumptions in the light of experimental data.
Previous course	Monitoring and Noise Protection http://www.ftn.uns.ac.rs/n1410122926/monitoring-i-zastita-od-buke

2.5 Traffic Engineering

Table 2.5.1 Course 'Acoustics and Audio Technique in Traffic' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Traffic Engineering – Postal Traffic and Telecommunication

	http://www.ftn.uns.ac.rs/n949146149/postanski-saobracaj-i-telekomunikacije
Course title	Acoustics and Audio Technique in Traffic http://www.ftn.uns.ac.rs/421412102/akustika-i-audio-tehnika-u-saobracaju
ECTS	4
Educational goals	• To present aspects of acoustics that are important for understanding the measurement and suppression of traffic noise, as well as audio techniques used in traffic for navigation and radio communication; • To describe the nature of sound and present the basics of the theory of sound formation and propagation of sound waves; • To explain what and how a human being hears, how he distinguishes the level and frequency content of sound and how he perceives the direction in which the sound source is located; • To explain how the transmission and perception of sound is affected by enclosed spaces such as rooms or car cabins; • To introduce audio signals (speech, music and noise) and audio techniques for recording and playback, as well as audio signal transmission; • To study standards and regulations on permissible noise levels and get acquainted with techniques for measuring, monitoring and noise protection.
Educational outcomes	Students will: • learn how sound waves are formed and propagated, which a human being hears and how sound affects a person, how it is recorded, transmitted and reproduced. • understand the differences in outdoor and indoor sound behavior. • be able to assess the acoustic environment (in terms of speech intelligibility, music quality, noise levels), to select and set the audio technique for recording speech, music and noise. • get acquainted with measurement standards and techniques for suppressing traffic noise, as well as the application of speech and audio technologies in navigation and digital radio.
Course structure and content	• Physical characteristics of sound (laws of creation and propagation of sound waves); • Perception of sound and human impact (hearing area; characteristics of speech, music and noise); • Room acoustics (absorption/reverberation and their impact on sound level and intelligibility, acoustic quality of professional spaces);

	• Electro-acoustic transducers (microphones, speakers and headphones), measuring devices, tools for analysis and processing of audio signals; • Recording audio signals (speech, music and noise; microphone selection and settings); • Noise (sources and ways of noise propagation, noise characteristics, calculation of noise levels and methods of noise protection); • Traffic noise (road, railway and aircraft noise; noise monitoring and mapping; traffic noise protection). • Instrumentation for noise measurement and analysis (phonometers, filters, noise spectrum (N-curves), dosimeters, software); • Application of speech and audio technologies in navigation systems (ASR and TTS, GPS, RDS - digital radio).
Teaching methods	Lectures are conducted using Power Point presentations that are available to students in .pdf format. Presentations with specially created audio and video clips and animations demonstrate and illustrate key details in the lectures. The first part of the course is followed by auditory exercises. The second part of the course is followed by exercises in the Laboratory of Acoustics and Speech Technologies at FTN. Visits to several companies and institutions in Novi Sad are arranged, where students will learn about the measurement devices and software for noise analysis, as well as the techniques of measurement, monitoring and noise protection. The students will write a midterm paper, whose defense is one of the exam prerequisites. Independent student work is supported through the web portal of the Chair of Telecommunications and Signal Processing - www.ktios.net.
Literature	1. P. Pravica, D. Drincic, Electroacoustics, VISER, Belgrade, 2006 (In Serbian). 2. M. Mijic, Audio Systems, Academic thought, Belgrade, 2011 (In Serbian). 3. V. Delic, Script, www.ktios.net, 2012 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modeling assumptions in the light of experimental data. This course has not been reaccredited.

3. Short modules

REMARK 1: It is assumed that a No&Vib module is taught during a two week-period in a semester that lasts15 weeks.

3.1 Occupational Safety Engineering

Table 3.1.1 Course 'Selected Chapters in Physics 1' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Occupational Safety Engineering
Course title	Selected Chapters in Physics 1
Educational goals	Acquisition of basic knowledge in physics. The course objective is to introduce students to the basic physical principles and laws necessary for the process analysis and phenomena in environmental engineering. Acquired knowledge is a necessary basis for further studying and reading the professional literature.
Educational outcomes	Acquired knowledge enables understanding of the basic physical principles serving in the measurement and analysis of the living environment state. The knowledge of theoretical basis of selected chapters in physics relevant for environmental engineering, as well as practical basis of the measurement and understanding of physical results. By the end of the course, students should be able to: • explain the meaning of the main characteristics of noise and vibration, and associated phenomena; • recognize examples where/when they appear, identifying their positive or negative aspects.
Course structure and content	Theoretical lectures: 1) Basic concepts of kinematics and dynamics of translational and rotational motion. Newton`s laws of dynamics. Conservation laws of momentum, angular momentum and energy. Newton`s law of gravity, cosmic speed. 2) Basic laws of statics and fluid dynamics: pressure dependence of the depth of fluid; Pascal`s law; Bernoulli`s equation. 3) Fundamentals of Thermodynamics of ideal gases: First and second law of thermodynamics; Carnot cycle; Internal combustion engine; Boltzmann statistics and its impact on the environment. 4) Mechanical waves: characteristics of sound; Intensity; Standing waves and resonance; Ultrasound and applications. • The concept of noise • Noise scale • Frequency hearing sensitivity and the concepts of infrasound and ultrasound • Amplitude hearing sensitivity and sound level • Speed of sound • Sound propagation - attenuation by propagation and diffraction of sound

	• The concept of passive noise protection • Sound pressure Vibrations • Definition of vibration - the difference between vibration and oscillation • Self-vibrations, natural frequencies and vibration modes o the concept and example of a rectangular surface • Basic and higher vibration harmonics o the notion and example of a taut string • Forced vibrations Practical training (experimental and computing practice): experiments done during the practice follow theoretical lecture, as well as computing practice, thus contributing to the better understanding of the theoretical knowledge, as well as deepening the knowledge. Impact of noise and vibration on humans • Occupational diseases caused by noise and vibration • Active noise protection
Teaching methods	Lectures; Computing Practice; Laboratory Practice and Consultations. The knowledge is checked during laboratory practice and final examination. The examination may be taken through two colloquiums where each represents a logical whole. Both colloquiums are taken in the written form. Colloquiums are held during semester when the lectures are carried out. Students who don`t take the examination through colloquiums have to take the entire examination consisting of the written and oral part. Written part of the final examination is eliminatory. Oral part of the final examination is eliminatory. Tutorial classes; On-line short module.
Literature	1. M. Satarić, Physics: Thermodynamics and Wave Motion, Faculty of Technical Sciences, Novi Sad,1997 (In Serbian). 2. Group of authors, Solved Problems in Physics: Part 1 Faculty of Technical Sciences, Novi Sad, 2004 (In Serbian). 3. Group of authors, Solved problems in physics: part 2 Faculty of Technical Sciences, Novi Sad, 2005 (In Serbian). 4. Group of authors, Experiments in physics: Faculty of Technical Sciences, Novi Sad, 2004 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modelling assumptions in the light of experimental data.

3.2 Environmental Engineering

Table 3.2.1 Course 'Selected Chapters in Physics 1' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Environmental Engineering
Course title	Selected Chapters in Physics 1
Educational goals	Acquisition of basic knowledge in physics. The course objective is to introduce students to the basic physical principles and laws necessary for the process analysis and phenomena in environmental engineering. Acquired knowledge is a necessary basis for further studying and reading the professional literature.
Educational outcomes	Acquired knowledge enables understanding of the basic physical principles serving in the measurement and analysis of the living environment state. The knowledge of theoretical basis of selected chapters in physics relevant for environmental engineering, as well as practical basis of the measurement and understanding of physical results. By the end of the course, students should be able to: • explain the meaning of the main characteristics of noise and vibration, and associated phenomena; • recognize examples where/when they appear, identifying their positive or negative aspects.
Course structure and content	Theoretical lectures: 1) Basic concepts of kinematics and dynamics of translational and rotational motion. Newton`s laws of dynamics. Conservation laws of momentum, angular momentum and energy. Newton`s law of gravity, cosmic speed. 2) Basic laws of statics and fluid dynamics: pressure dependence of the depth of fluid; Pascal`s law; Bernoulli`s equation. 3) Fundamentals of Thermodynamics of ideal gases: First and second law of thermodynamics; Carnot cycle; Internal combustion engine; Boltzmann statistics and its impact on the environment. 4) Mechanical waves: characteristics of sound; Intensity; Standing waves and resonance; Ultrasound and applications. • The concept of noise • Noise scale • Frequency hearing sensitivity and the concepts of infrasound and ultrasound • Amplitude hearing sensitivity and sound level • Speed of sound • Sound propagation - attenuation by propagation and diffraction of sound • The concept of passive noise protection • Sound pressure Vibrations

	• Definition of vibration - the difference between vibration and oscillation • Self-vibrations, natural frequencies and vibration modes o the concept and example of a rectangular surface • Basic and higher vibration harmonics o the notion and example of a taut string • Forced vibrations Practical training (experimental and computing practice): experiments done during the practice follow theoretical lecture, as well as computing practice, thus contributing to the better understanding of the theoretical knowledge, as well as deepening the knowledge. Impact of noise and vibration on humans • Occupational diseases caused by noise and vibration • Active noise protection
Teaching methods	Lectures; Computing Practice; Laboratory Practice and Consultations. The knowledge is checked during laboratory practice and final examination. The examination may be taken through two colloquiums where each represents a logical whole. Both colloquiums are taken in the written form. Colloquiums are held during semester when the lectures are carried out. Students who don`t take the examination through colloquiums have to take the entire examination consisting of the written and oral part. Written part of the final examination is eliminatory. Oral part of the final examination is eliminatory. Tutorial classes; On-line short module.
Literature	1. M. Satarić, Physics: Thermodynamics and Wave Motion, Faculty of Technical Sciences, Novi Sad,1997 (In Serbian). 2. Group of authors, Solved Problems in Physics: Part 1 Faculty of Technical Sciences, Novi Sad, 2004 (In Serbian). 3. Group of authors, Solved problems in physics: part 2 Faculty of Technical Sciences, Novi Sad, 2005 (In Serbian). 4. Group of authors, Experiments in physics: Faculty of Technical Sciences, Novi Sad, 2004 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modelling assumptions in the light of experimental data.

3.3 Mechanical Engineering

Table 3.3.1 Course 'Technical Physics' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Energy and Process Engineering; Production Engineering; Mechanization and Construction Engineering; Technical Mechanics and Technical Design
Course title	Technical Physics
Educational goals	Acquisition of basic knowledge in technical physics.
Educational outcomes	Basic knowledge in technical physics. By the end of the course, students should be able to: • explain the meaning of the main characteristics of noise and vibration, and associated phenomena; • recognize examples where/when they appear, identifying their positive or negative aspects.
Course structure and content	Fundamental forces and conservation laws. Special theory of relativity. Fundamentals of electrostatics. Electric field and potential. Conductors and dielectric in an electric field. Electricity. DC, resistance. Modern theory of conductivity. Semiconductors. Electromagnetism. The magnetic field of electricity. Electromagnetic induction. Magnetic field energy. AC. Magnetic field in the material. Diamagnetism, paramagnetism, ferromagnetism. Wave propagation and acoustics. Wave equation. Doppler effect. Power and volume. The absorption of sound. Ultrasound. • Wave superposition o The term o Wave interference • Waves in space o Superposition of waves emanating from different sources o Wave fronts o Wave rays o Huygens principle o Shapes of wave fronts o Wave intensity o Wave diffraction o Wave repulsion o Wave refraction Strength and strength level of sound. Sound reflection and absorption. • The concept of noise • Noise scale • Amplitude hearing sensitivity and sound level • Speed of sound • Sound propagation - attenuation by propagation and diffraction of sound • The concept of passive noise protection • Sound pressure Impact of noise and vibration on humans • Occupational diseases caused by noise and vibration • Active noise protection

	Optics. The basic laws of geometrical optics. Regular reflection. Diffuse reflection. Index refraction. Dispersion. Optical instrument. Wave optics. Polarization. Diffraction of light and X – ray diffraction. Color. Dualism of light. Heat radiation. Black body and Planck law. Photoeffect. Stimulated emission. Lasers. Physical basis of nuclear engineering. Radioactive decays. Nuclear reactors. Particle accelerators.
Teaching methods	Lectures; Laboratory Practice; Computing Practice; Consultations. Lectures; Tutorial classes plus a practical exercise; On-line short module.
Literature	1. A. Petrović, Fundamentals of Physics, University of Novi Sad, Faculty of Technical Sciences, 2007, (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modelling assumptions in the light of experimental data.

Table 3.3.2 Course 'Physics' at UniKG

University	University of Kragujevac
Faculty	Faculty of Mechanical and Civil Engineering in Kraljevo
Study programme	Mechanical Engineering
Course title	Physics
Educational goals	The course should provide students an insight into the common physical foundations of the objects and processes involved in mechanical engineering, as well as introduce them to the exact approach to the study and description of those objects and processes.
Educational outcomes	By the end of the course, the student: • knows the SI system units and converts units outside the SI system to the SI system; understands measurement error and knows how to determine absolute and relative measurement and calculation error; • understands basic physical concepts, is able to define appropriate physical quantities and formulate laws that apply to them; • knows fundamental interactions and understands how electromagnetic interactions determine the structure of atoms and bodies, as well as how gravitational interactions determine the structure of the cosmos; knows how to define and calculate macroscopic forces and associated energies;

	• understands the meaning of the main characteristics of mechanical waves (especially noise and vibration) and electromagnetic waves (especially light) and associated phenomena; recognizes the examples where/when they appear, identifying their positive and negative aspects.
Course structure and content	45 classes of lectures + 18 classes of exercises in classroom + 12 classes of exercises in laboratory Theoretical lectures: Concepts and types of physical quantities and units, rules of dimensional analysis and rules for conversion of physical units. The concept of physical quantity, direct and indirect measurements, and errors of direct and indirect measurements. Basic physical concepts that describe nature: concept of matter (substance and physical field), change, motion, force, work, energy, system, symmetry and the laws of conversion; application of the basic physical concepts to important cases of motion of material points - rectilinear motion, motion in the gravitational field of the Earth, circular motion, periodic motion with oscillations and collisions; Interaction in nature: fundamental interactions with the study of structure of the matter from the level of cosmos (Kepler's laws) to the atomic level (Bohr's model of atoms); forces among atomic particles and the concepts of internal energy and heat with the principles of thermodynamics and study of the structure of a body in different aggregate states; the concepts of phases, phase transitions and latent heat; macroscopic forces acting between objects in mechanical engineering (normal reaction force, forces of pressure and buoyance, elastic and surface tension forces, dry and viscous friction forces). Wave processes: concept, kinds, types and speed of waves; waveforms, characteristics of transients, continuous waves, periodic and harmonic waves; Doppler effect; spectrum of periodic waves, classification of mechanical and electromagnetic waves according to the wavelength; formation and propagation of waves, concepts of wave-fronts and wave-rays; superposition and the Huygens principle; wave energy and intensity, sound level and sound pressure; wave interference and standing waves, diffraction and diffraction grating, wave dispersion; wave reflection and transmission, laws of wave repulsion and refraction, total reflection; the notion of vibrations, vibrations of rods, self and forced vibrations, resonances; vibrations and sound emission. Exercises: Computational exercises to illustrate solving of simple physical tasks and problems. Laboratory exercises where students are introduced to the principles of the experimental method of studying objects and processes.

Teaching methods	Theoretical concepts are presented in the form of lectures, selected problems are solved on the board with student participation, and experimental work is made in the laboratory with report writing and oral discussion.
Literature	1. M. Vujović, Physics, Faculty of Mechanical Engineering in Kraljevo, Kraljevo, 2002 (In Serbian). 2. Z. Šoškić, Collection of Problems in Technical Physics, Faculty of Mechanical and Civil Engineering in Kraljevo, Kraljevo, 2016 (In Serbian). 3. Z. Šoškić, Problem Solving in Physics, Faculty of Mechanical Engineering, Kraljevo, Kraljevo 2011 (In Serbian). 4. Z. Šoškić, Laboratory Exercises in Physics, Faculty of Mechanical Engineering Kraljevo, Kraljevo 2011 (In Serbian). 5. V.Vucic, Basic Measurements in Physics, Naučna knjiga, Belgrade, 1984 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modelling assumptions in the light of experimental data.

3.4 Electrical Engineering

Table 3.4.1 Course 'Physics' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Power, Electronic and Telecommunication Engineering Measurement and Control Engineering
Course title	Physics
Educational goals	Provide students with basic knowledge in basic physics laws, particularly thermodynamics, wave motion and the basis of atomic physics, with an emphasis on their application in electronics.
Educational outcomes	Acquired knowledge will be used in professional courses for understanding the physical essence of technical processes. By the end of the course, students should be able to: • explain the meaning of the main characteristics of noise and vibration, and associated phenomena; • recognize examples where/when they appear, identifying their positive or negative aspects.
Course structure and content	Atomic and molecular structure of matter. Maxwell and Boltzmann statistics of micro particles. Zero, first, second and third

	law of thermodynamics. Phase transitions, meting and boiling. Kinetic properties, diffusion, heat conduction, viscosity. Periodic motion • Period of time • Frequency • Mechanical oscillations Harmonic mechanical oscillations • The notion of oscillator stiffness • Equation of harmonic oscillation • Elongation • Amplitude of harmonic oscillations • Speed and acceleration of harmonic oscillation • Phase of harmonic oscillations • Harmonic oscillator energy Progressive mechanical waves. Ultrasound and application. Doppler effect and application. Physical and physiological sound intensity. • The concept of noise • Noise scale Vibrations • Definition of vibration - the difference between vibration and oscillation • Self-vibrations, natural frequencies and vibration modes o the concept and example of a rectangular surface • Basic and higher vibration harmonics o the notion and example of a taut string • Forced vibrations • Resonance Impact of noise and vibration on humans • Occupational diseases caused by noise and vibration • Active noise protection Electromagnetic waves, the classical Hertzian dipole, Bohr model of the atom, Photon emission, Photo effect and Compton effect. De Brogile duality, electronic microscope. Geometrical optics, wave refraction, lens, microscope. Wave optics, interference, diffraction, dispersion, polarization. Elementary principles of Quantum Mechanics, Schrödinger equation, Heisenberg's principle. Fermi – Dirac distribution.
Teaching methods	Two logical wholes, thermodynamics and wave motion can be passed through two colloquiums. Colloquium is part of the examination. Colloquium and examination are written and oral. Written part is eliminating. Oral part is taken orally. Lectures; Tutorial classes plus a practical exercise. On-line short module.
Literature	1. M.V. Sataric, Physics, Faculty of Technical Sciences, Novi Sad, 2006 (In Serbian). 2. M.V. Satarić, A. Mihajlović, Experiments in Physics, , Faculty of Technical Sciences, Novi Sad, 2010 (In Serbian).

	3. M. Satarić et al., Solved Problems in Physics, Faculty of Technical Sciences, Novi Sad, 1998 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: •translate mathematical formulations into computer codes; •question the validity of modelling assumptions in the light of experimental data.

Table 3.4.2 Course 'Physics' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Computing and Control Engineering
Course title	Physics
Educational goals	Provide students with basic knowledge about physics.
Educational outcomes	Acquired knowledge will be used for understanding the physical processes underlying the operation of computers and other technical equipment. By the end of the course, students should be able to: • explain the meaning of the main characteristics of noise and vibration, and associated phenomena; • recognize examples where/when they appear, identifying their positive or negative aspects.
Course structure and content	Kinematics and dynamics of translational and rotational movement. Force. Newton's laws and laws of conservation. Field of gravity. Harmonic oscillations. Special theory of relativity. Fundamentals of physics of plasma(fusion). Fundamentals of fluid mechanics. First and second principle of thermodynamics. Phase transitions. Maxwell and Boltzmann distribution. Physical kinetics. Diffusion, heat conduction, viscosity. Wave movement, mechanical and electromagnetic waves. • Doppler effect • Wave superposition o The term o Wave interference • Waves in space o Superposition of waves emanating from different sources o Wave fronts o Wave rays o Huygens principle o Shapes of wave fronts o Wave intensity o Wave diffraction o Wave repulsion o Wave refraction

	Sound • The concept of sound • The concept of noise • Noise scale • Frequency hearing sensitivity and the concepts of infrasound and ultrasound • Amplitude hearing sensitivity and sound level • Speed of sound • Sound propagation - attenuation by propagation and diffraction of sound • The concept of passive noise protection • Sound pressure Basics of acoustics • Reverberation, absorption, room absorption, absorption coefficient • Reverberation time • Assessment of the acoustic environment Vibrations • Definition of vibration - the difference between vibration and oscillation • Self-vibrations, natural frequencies and vibration modes o the concept and example of a rectangular surface • Basic and higher vibration harmonics o the notion and example of a taut string • Forced vibrations • Resonance Impact of noise and vibration on humans • Occupational diseases caused by noise and vibration • Active noise protection Wave and geometrical optics. Fundamentals of quantum physics. Schrödinger equation and its applications. Fermi – Dirac distribution and its application in seminconductors. Elements of solid state physics. Bose – Einstein distribution and its application on LASERs and superconductors.
Teaching methods	Lectures, laboratory practice, computation practice, consultations. In lecture classes the theoretical part is presented with suitable examples to illustrate the application of theory and task solving. Laboratory practice covers experiments in the fields covered by the curriculum. Computation practice is given to characteristic tasks, and deepening of knowledge presented during the lectures. In addition to this there are regular consultations. Parts of the subject matter which presents a logical whole can be taken in the form of partial exams or colloquia. The final examination consists of written and oral part with the written part being eliminating. Lectures; Tutorial classes plus a practical exercise. On-line short courses.
Literature	1. Lj. Budinski-Petković, Physics, Faculty of Technical Sciences, Novi Sad, 2008 (In Serbian).

	2. D. Ćirić, A. Kozmidis-Petrović et al., Sloved Problems in Physics Part I, Faculty of technical sciences, Novi Sad, 2004 (In Serbian). 3. M. Satarić, U. Kozmidis-Luburić, Lj. Budinski-et al., Solved problems in physics part II, Faculty of technical sciences, Novi Sad, 2005 (In Serbian). 4. Lj. Budinski-Petković, M. Vučinić-Vasić, D. Ilić, Experiments in physics, Faculty of technical sciences, Novi Sad, 2005, (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modelling assumptions in the light of experimental data.

3.5 Civil Engineering

Table 3.5.1 Course 'Civil Engineering Physics' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Civil Engineering
Course title	Civil Engineering Physics
Educational goals	Acquiring basic knowledge in civil engineering physics important for civil engineering profession.
Educational outcomes	Basic knowledge in civil engineering physics. By the end of the course, students should be able to: • explain the meaning of the main characteristics of noise and vibration, and associated phenomena; • recognize examples where/when they appear, identifying their positive or negative aspects.
Course structure and content	Gravitation and electro-magnetic interaction. Basics in electrostatics. Electrical field and potential. Conductors and dielectrics in an electric field. Electric currents. Direct currents, resistance. Contemporary theory on electrical conductivity. Electrical magnetism. Magnetic field of currents. Electro-magnetic induction. Magnetic field energy. Alternating currents. Oscillatory movement, vibrations, waves. Free variations. Damped oscillations. Forced vibrations. Wave equations. Doppler effect. • Wave superposition o The term o Wave interference • Waves in space o Superposition of waves emanating from different sources o Wave fronts

	o Wave rays o Huygens principle o Shapes of wave fronts o Wave intensity o Wave diffraction o Wave repulsion o Wave refraction Strength and strength level of sound. Sound reflection and absorption. • The concept of noise • Noise scale • Amplitude hearing sensitivity and sound level • Speed of sound • Sound propagation - attenuation by propagation and diffraction of sound • The concept of passive noise protection • Sound pressure Basics of acoustics • Reverberation, absorption, room absorption, absorption coefficient • Reverberation time • Assessment of the acoustic environment Impact of noise and vibration on humans • Occupational diseases caused by noise and vibration • Active noise protection Ultrasound. Optics. Fundamental laws in geometric optics. Reflection, dispersion and color of a body. Wave optics. Polarization. Light diffraction and X ray diffraction. Photometry. Quantum characteristics of light, photo effect, lasers. Elements of the science on heat. Internal energy. Specific heat. Phase transitions. Air humidity. Heat expansion and stresses. Heat conductivity. Water vapor diffusion through walls. Airing. Heat radiation. Black body and Planck`s law.
Teaching methods	Lectures; Laboratory practice; Computing practice. Tutorial classes; On – line short module.
Literature	1. A. Petrović, Civil Engineering Physics, University of Novi Sad, Faculty of Technical Tciences, 2004 (In Serbian). 2. M. Vučinić-Vasić, D. Ćirić, T. Škrbić, M. Đurić, Solved Problems in Physics, 2005 (In Serbian). 3. Lj. Budinski Petkovic, S. Grujic, D. Ilic, Experiments in Physics, 2006 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes;

	• question the validity of modelling assumptions in the light of experimental data.

Table 3.5.2 Course 'Technical Physics' at UniKG

University	University of Kragujevac
Faculty	Faculty of Mechanical and Civil Engineering in Kraljevo
Study programme	Civil Engineering
Course title	Technical Physics
Educational goals	Introducing students to the physical basis of natural processes studied in civil engineering
Educational outcomes	By the end of the course, the student: • knows the SI system units and converts units outside the SI system to the SI system; understands measurement error and knows how to determine absolute and relative measurement and calculation error; • understands basic physical concepts, is able to define appropriate physical quantities and formulate laws that apply to them; • knows fundamental interactions and understands how electromagnetic interactions determine the structure of atoms and bodies, as well as how gravitational interactions determine the structure of the cosmos; knows how to define and calculate macroscopic forces and associated energies; • understands the meaning of the main characteristics of mechanical waves (especially noise and vibration) and electromagnetic waves (especially light) and associated phenomena; recognizes the examples where/when they appear, identifying their positive and negative aspects;
Course structure and content	45 classes of lectures + 18 classes of exercises in classroom + 12 classes of exercises in laboratory <u>Theoretical lectures:</u> Concepts and types of physical quantities and units, rules of dimensional analysis and rules for conversion of physical units. The concept of physical quantity, direct and indirect measurements, and errors of direct and indirect measurements. Basic physical concepts that describe nature: concept of matter (substance and physical field), change, motion, force, work, energy, system, symmetry and the laws of conversion; application of the basic physical concepts to important cases of motion of material points - rectilinear motion, motion in the gravitational field of the Earth, circular motion, periodic motion and oscillations; Interaction in nature: fundamental interactions with the study of structure of the matter from the level of cosmos (Kepler's laws) to the atomic level (Bohr's model of atoms); forces among atomic particles and the concepts of internal energy and heat with the principles of thermodynamics and study of the structure of a body in different aggregate states; the concepts of phases, phase transitions and latent heat; macroscopic forces acting between objects in mechanical engineering (normal reaction force, forces

	of pressure and buoyance, elastic and surface tension forces, dry and viscous friction forces). Wave processes: concept, kinds, types and speed of waves; waveforms, characteristics of transients, continuous waves, periodic and harmonic waves; Doppler effect; spectrum of periodic waves, classification of mechanical and electromagnetic waves according to the wavelength; formation and propagation of waves, concepts of wave-fronts and wave-rays; superposition and the Huygens principle; wave energy and intensity, sound level and sound pressure; wave interference and standing waves, diffraction and diffraction grating, wave dispersion; wave reflection and transmission, laws of wave repulsion and refraction, total reflection; the notion of vibrations, vibrations of rods, self and forced vibrations, resonances; vibrations and sound emission. Exercises: Computational exercises to illustrate solving of simple physical tasks and problems. Laboratory exercises where students are introduced to the principles of the experimental method of studying objects and processes.
Teaching methods	Theoretical concepts are presented in the form of lectures, selected problems are solved on the board with student participation, and experimental work is made in the laboratory with report writing and oral discussion.
Literature	1. V. Georgijević, Technical Physics, Faculty of Civil Engineering of University of Belgrade, Belgrade, 2005 (In Serbian). 2. M. Vujović, Physics, Faculty of Mechanical Engineering in Kraljevo, Kraljevo 2002 (In Serbian). 3. Z. Šoškić, Collection of Problems in Technical Physics", Faculty of Mechanical and Civil Engineering in Kraljevo, Kraljevo, 2016 (In Serbian). 4. Z. Šoškić, Problem Solving in Physics, Faculty of Mechanical Engineering, Kraljevo, Kraljevom 2011 (In Serbian). 5. Z. Šoškić, Laboratory exercises in Physics, Faculty of Mechanical Engineering Kraljevo, Kraljevo 2011 (In Serbian). 6. V. Vucic, Basic Measurements in Physics, Naučna knjiga, Belgrade, 1984 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modelling assumptions in the light of experimental data.

3.6 Traffic Engineering

Table 3.6.1 Course 'Physics' at UNS

University	University of Novi Sad
Faculty	Faculty of Technical Sciences
Study programme	Traffic and Transport Engineering
Course title	Physics
Educational goals	Gaining fundamental knowledge in physics.
Educational outcomes	Students understand phenomena and processes in engineering based on laws of physics. By the end of the course, students should be able to: • explain the meaning of the main characteristics of noise and vibration, and associated phenomena; • recognize examples where/when they appear, identifying their positive or negative aspects.
Course structure and content	Physics and its methods in space and time. Mechanics of material point (kinematics and dynamics). Newton`s laws. Physics of surfaces. Elastic properties of micro bodies. Oscillations. Fundamentals of field. Work, power and energy. Gravitation. Elements of special theory of relativity. Thermal physics (ideal and real systems, phase transitions, aggregate states of matter, and ways of heat transmission, basic of thermodynamic and thermodynamic systems). Wave movement. • Wave superposition o The term o Wave interference • Waves in space o Superposition of waves emanating from different sources o Wave fronts o Wave rays o Huygens principle o Shapes of wave fronts o Wave intensity o Wave diffraction o Wave repulsion o Wave refraction Acoustics (sound waves, intensity of sound waves, ultrasound, Doppler effect). • The concept of noise • Noise scale • Amplitude hearing sensitivity and sound level • Speed of sound • Sound propagation - attenuation by propagation and diffraction of sound • The concept of passive noise protection Impact of noise and vibration on humans • Occupational diseases caused by noise and vibration • Active noise protection

	Optics (wave, physical, quant). Physics of the micro world.
Teaching methods	Lectures, computation practice, laboratory practice and consultations. Lectures; Tutorial classes plus a practical exercise; On-line short module.
Literature	1. U. Kozmidis-Luburić, Lj. Budinski-Petković, S. Grujić, M. Vučinić-Vasić, D. Ilić, A. Mihailović, Experiments in Physics-Traffic Engineering and Transport, FTN-Novi Sad, 2014 (In Serbian). 2. U. Kozmidis Luburić, S. Grujić, Physics, 2016, FTN-Novi Sad, 2016 (In Serbian). 3. U. Kozmidis Luburić, S. Grujić, M. Vučinić Vasić, I. Stojković, A. Antić, Solved Problems in Physics- Traffic Engineering and Transport, FTN-Novi Sad, 2014 (In Serbian).
Notes on course content and appropriate teaching/learning methodologies	E- or b-teaching/learning methodologies should be used to enable students not only to achieve the educational outcomes defined but also to acquire transferable and generic skills described in the comments below.
Comments	The following transferable and generic skills should be developed: • translate mathematical formulations into computer codes; • question the validity of modelling assumptions in the light of experimental data.

4. Summary and future work

This Report, together with the SENVIBE Report on New Courses[2], gives certain overview of the education on No&Vib at four Serbian universities from the SENVIBE consortium: University of Novi Sad (UNS), University of Nis (UNI), University of Kragujevac (UniKG) and Educons University from Sremska Kamenica (EUSK) and their respective faculties (one per each): Faculty of Technical Sciences in Novi Sad, Faculty of Occupational Safety in Nis, Faculty of Mechanical and Civil Engineering in Kraljevo and Faculty of Environmental Protection in Sremska Kamenica. These two Reports cover the courses on No&Vib for students of six different engineering study programmes: Occupational Safety, Environmental, Mechanical, Electrical, Civil and Traffic Engineering. Unlike the SENVIBE Report on New Courses[2], which includes four new courses developed during the SENVIBE project (one at EUSK, two at UNS, and one jointly at UNS and UniKG), this Report has been concerned with the redesign of five existing courses that have been updated by the SENVIBE team from various viewpoints (learning goals, learning outcomes, content, teaching methodologies, new teaching & learning material), which have been described in the following Tables: 2.1.1 (UNI), 2.1.2 (UNS), 2.2.1 (UNS), 2.3.3 (UniKG) and 2.3.4 (UniKG). This Report also includes four courses accredited or taught by teachers outside the SENVIBE team, which are given in the following Tables: 2.3.1 (UNS), 2.3.2 (UNS), 2.4.1 (UNS) and 2.5.1 (UNS). As they will also have the new teaching & learning material at their disposal, it is hoped that they will benefit from the SENVIBE results as well. The third important group covered in this proposal are short modules for nine courses in Physics developed during the SENVIBE project, which have been described in the following Tables: 3.1.1 (UNS), 3.2.1 (UNS), 3.3.1 (UNS), 3.3.2 (UniKG), 3.4.1 (UNS), 3.4.2 (UNS), 3.5.1 (UNS), 3.5.2 (UniKG) and 3.6.1 (UNS).

Comparing the number of the newly developed and redesigned courses as a result of the SENVIBE project activities with respect to the planned in the proposal (four redesigned and two new ones) and adding the number of short modules developed, it is seen that the results outperform the plans in a remarkable manner.

The next step regards the implementation of the course and modules, enhanced with the use of the e-SENVIBE platform

https://www.e-senvibe.senvibe.uns.ac.rs/

and the newly developed learning material. This will be carefully monitored, and the associated statistics will be collected to assess them quantitatively and qualitatively.

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