



COURSE DESCRIPTION CARD - SYLLABUS

Course name

Technical mechanics [S1MiBM2>MT2]

Course

Field of study

Mechanical Engineering

Year/Semester

2/3

Area of study (specialization)

–

Profile of study

general academic

Level of study

first-cycle

Course offered in

Polish

Form of study

full-time

Requirements

compulsory

Number of hours

Lecture

15

Laboratory classes

15

Other

0

Tutorials

15

Projects/seminars

0

Number of credit points

4,00

Coordinators

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Lecturers

Prerequisites

Basic knowledge of mathematics: vector, differential, and integral calculus, complex numbers, linear algebra, Fourier series; and basic knowledge of technical mechanics: statics, kinematics, and dynamics. Ability to think logically and creatively, and use the internet and library resources. Social competences: understanding the need for continuous learning and acquiring new knowledge.

Course objective

To deepen students' knowledge of technical mechanics, particularly regarding vibrations of mechanical systems and an introduction to the dynamics of rotating machines. To consolidate knowledge of statics, kinematics, and dynamics through experimental work.

Course-related learning outcomes

Knowledge:

The student has a structured understanding of the main areas of technical mechanics: statics, kinematics, and dynamics of a material point and a rigid body. The student has knowledge of mechanical vibrations, their importance in machine design, their sources, causes, and effects, their mathematical description, and methods for vibration minimization. The student understands the principles of building physical and

mathematical models of mechanical systems with single and multiple degrees of freedom. They have a foundation for further study of issues related to machine dynamics.

Skills:

The student can obtain information from literature, the internet, databases, and other sources. The student can integrate, interpret, and draw conclusions from the obtained information, and formulate and justify opinions. The student can use acquired theories to create and analyze physical and mathematical models of machines and their components. The student can calculate vibration amplitudes and natural frequencies of mechanical systems analytically and using approximate methods. The student can identify dynamic properties in mechanical systems. Is able to apply vibration minimization methods. Is able to incorporate acquired knowledge into the design and operation of machinery.

Social competencies:

Recognizes the importance of knowledge in solving cognitive and practical problems and seeks expert advice when faced with difficulties in solving a problem independently. Is ready to perform professional roles responsibly. Understands the importance of their decisions regarding technical systems through their impact on the environment and the operator. Is aware of the harmful impact of vibrations on people, buildings, and machinery and understands the need to minimize them.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture credit based on a written exam graded according to the following scale:

<50% - nsf,
<50% - 60%) - nsf,
<60% - 70%) - nsf+,
<70% - 80%) - sf,
<80% - 90%) - sf+,
<90% - 100%> - vg.

Assessment of exercises based on quizzes and class participation. Grading according to the following scale:

<50% - nsf,
<50% - 60%) - nsf,
<60% - 70%) - nsf+,
<70% - 80%) - sf,
<80% - 90%) - sf+,
<90% - 100%> - vg.

Completion of the laboratory course requires completion of 100% of the exercises and 100% of the reports from the exercises, each with a minimum score of 50%, and 100% of the tests passed (with the possibility of retaking them twice). The final grade is based on the sum of points earned for the reports and short tests verifying preparation. Grading is based on the following scale:

<50% - undeclared,
<50% - 60% - satisfactory,
<60% - 70% - satisfactory+,
<70% - 80% - satisfactory,
<80% - 90% - satisfactory+,
<90% - 100%> - very satisfactory.

Programme content

Lecture

1. Introduction. Basic definitions of vibration. The importance of mechanical vibrations in machine design. Vibration classification. Vibration sources in machines and devices.

2. Modeling vibrating systems. Creating a physical model. Determining the reduced parameters: mass, stiffness, and damping. Discretization of continuous systems. Damping models.

3. Construction of a mathematical model - balance model and Lagrange's equations of the second kind. Description of free vibrations of a single-degree-of-freedom system with and without damping. Parameters characterizing damping and their determination. Identification of dynamic parameters based on free vibrations.

4. Description of harmonically forced vibrations of a single-degree-of-freedom system with and without damping. Resonance and beat phenomena. Dynamic characteristics.
5. Periodic excitation - application of Fourier series. Self-excited vibrations. Parametric vibrations. Inertial excitation. Short-term excitation. Random excitation.
6. Kinematic excitation. Force and displacement vibration isolation. Vibration isolator selection. Geiger's formula. Basics of vibration measurement.
7. Description of the motion of two- and multi-degree-of-freedom systems. Vibration frequencies and modes. Vibration elimination - dynamic vibration eliminator, theoretical foundations, tuning principle. Bending and torsional vibrations of shafts. Modeling the shaft and bearing system.
8. Basics of mechanical system identification, dynamic tests. Frequency response function. Numerical solution of dynamic equations of motion.

Exercises

1. Introductory exercises
 2. Linear, free, undamped vibrations - construction of a physical model and construction of a mathematical model using the balance method. Determining the frequency of free, undamped vibrations
 3. Linear, free, and damped vibrations - building a physical model and building a mathematical model using the balance method. Determining the frequency of free, damped vibrations
 4. Linear, free, undamped, and damped vibrations - modeling systems using the Lagrange equations of the second kind.
 5. Harmonically forced, damped, and undamped vibrations - modeling systems using the balance method and using the Lagrange equations of the second kind.
 6. Harmonically forced, damped, and undamped vibrations - modeling systems using the balance method and using the Lagrange equations of the second kind - continued. Determining vibration amplitudes.
 7. Modeling a two-degree-of-freedom system. Vibration frequencies and mode shapes. Torsional vibrations of shafts - modeling the system.
 8. Selecting vibration isolation. Tuning the dynamic eliminator. Experimental Mechanics Laboratory
- #### 1. Introductory Classes
2. Determining the Moments of Inertia of Machine Elements - Three-Point Suspension Method
 3. Determining the Moments of Inertia of Machine Elements - Physical Pendulum Method
 4. Precessional Motion of a Gyroscope
 5. Determining the Coefficients of Kinematic and Static Friction
 6. Determining the Mechanical Energy in Plane Motion
 7. Determining the Coefficient of Restitution
 8. Examining the Equilibrium of Plane Convergent and Plane Non-Convergent Force Systems.

Course topics

This course covers the fundamentals of modeling and describing mechanical vibrations in linear discrete systems with single and multiple degrees of freedom. Discretization methods for continuous systems are also presented. The course also covers issues related to vibration minimization, particularly vibration isolation, vibration eliminators, and minimization through changes in dynamic system parameters. The course also provides an introduction to the dynamics of rotating machines, including modeling lateral and torsional vibrations of shafts and determining their frequencies and vibration modes.

Teaching methods

Multimedia presentations on theory and examples of practical calculations. Blackboard exercises. Implementation of multi-variant laboratory exercises (each student performs their own exercise variant).

Bibliography

Basic:

1. K. Arczewski et al., Vibrations of Physical Systems, Warsaw University of Technology Publishing House, Warsaw 2008
2. J. Giergiel, Vibrations of Mechanical Systems, textbook 1037, AGH University of Science and Technology Textbooks, Cracow 1986
3. Z. Parszewski, Vibrations and Dynamics of Machines, WNT, Warsaw 1982
4. J. Bajkowski et al., Collection of Problems on the Theory of Vibrations, PWN, Warsaw 1989
5. W. Sałata, General Mechanics in Outline, Poznań, PP Publishing House 1998
6. J. Leyko, General Mechanics. Vol. 1 and 2, Warsaw, PWN 2008.

7. Laboratory Exercise Instructions

Supplementary:

1. Osowski Z., Damping of Mechanical Vibrations, PWN Warsaw 1986
2. Giergiel J., Uhl T., Identification of Mechanical Systems, PWN, Warsaw 1990
3. Harris C.M., Crede C.E., Shock and Vibration Handbook, McGRAW-HILL, New York 1976
4. Kelly S.G., Mechanical Vibrations, Theory and Application, The University of Akron, 2011

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	47	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	53	2,00