**Nazwa przedmiotu:**

Mechanical Vibrations

**Koordynator przedmiotu:**

dr inż. Bogumił Chiliński

**Status przedmiotu:**

Obowiązkowy

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Electric and Hybrid Vehicles Engineering

**Grupa przedmiotów:**

Obowiązkowe

**Kod przedmiotu:**

1150-00000-ISA-0213

**Semestr nominalny:**

4 / rok ak. 2022/2023

**Liczba punktów ECTS:**

4

**Liczba godzin pracy studenta związanych z osiągnięciem efektów uczenia się:**

1) Student work with tutor - 50 hours, including:
a) lecture - 30 hours;
b) tutorials - 15 hours;
c) consultations - 2 hours;
d) exam - 3 hours.
2) Independent student work - 60 hours, including:
a) student preparing for lectures - 15 hours;;
b) literature investigation - 15 hours;
c) student preparing for test- 15 hours;
d) student preparing for exam- 15 hours.
3) TOTAL – 110 hours

**Liczba punktów ECTS na zajęciach wymagających bezpośredniego udziału nauczycieli akademickich:**

Student work with tutor - 50 hours, including:
a) lecture - 30 hours;
b) tutorials- 15 hours;
c) consultations - 2 hours;
d) exam - 3 hours.

**Język prowadzenia zajęć:**

angielski

**Liczba punktów ECTS, którą student uzyskuje w ramach zajęć o charakterze praktycznym:**

No separate credits for lecture and class.

**Formy zajęć i ich wymiar w semestrze:**

|  |  |
| --- | --- |
| Wykład:  | 30h |
| Ćwiczenia:  | 15h |
| Laboratorium:  | 0h |
| Projekt:  | 0h |
| Lekcje komputerowe:  | 0h |

**Wymagania wstępne:**

Knowledge and skills concerning:
- Basic algebra incl. matrices and linear equations,
- differential and integral calculus,
- differential equations,
- complex numbers and their calculus,
- principles of mechanics – linear and angular momentum laws, kinetic energy law,
- Lagrange equations for multi-body systems,
- basic knowledge on strength of materials

**Limit liczby studentów:**

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**Cel przedmiotu:**

Understanding the nature and physical sources of vibrations in mechanical systems, incl. excitation and damping of vibrations; modeling and analysis of linear vibrations of discrete and continuous systems; phenomenon of resonance and reducing g resonant amplitudes; knowledge and practical skills in solving simple model problems of vibrations – natural frequencies and eigen-forms in discrete and continuous systems, resonant curves, dynamical vibration absorber, the role of damping; parametric excitation and self-excitation of vibrations.

**Treści kształcenia:**

Lecture:

1. Introduction (2 hrs)
Importance of vibrations in machines and vehicles. Models of vibrating systems and proce4sses. Harmonic motion. Synthesis of harmonic motions. Elements of harmonic analysis. Classification of vibrations. Derivation of equations of motion.

2. Vibrations of single-degree-of-freedom systems (6 hrs)
Free vibrations with viscous damping. Logarithmic damping decrement. Vibrations excite4d by harmonic force. Resonance. Amplitude-frequency characteristics. Vibrations under periodic and arbitrary excitations. Impulse transfer function. Kinematically excited vibration. Seismic vibration sensor. Vibroisolation.

3. Analysis of vibrations on the phase plane (4 hrs)
Phase plane. Phase trajectory and phase portrait. Singular points. Types of singular points in linear systems and their stability. Płaszczyzna fazowa. Trajektorie fazowe. Obraz fazowy. Separating trajectories in nonlinear systems. Sketching phase portraits.

4. Vibrations of linear multi-degree-of-freedom systems (6 hrs)
Free undamped vibrations. Eigen-frequencies. And eigen-forms. General solution of equations of motion. Solution satidfying initial conditions. Damped vibrations. Excited vibrations. Resonant curves. Dynamic vibration absorber.

5. Vibrations of one-dimensional linear continuous systems (6 hrs)
Equations of motion of a string, rod, shaft and beam. Initial and boundary problems. Initial and boundary conditions. Eigen-numbers, eigen-functions and eigen-frequencies. Orthogonality conditions of eigen-functions. Free vibrations. Vibrations excited by distributed time-dependent loads. Kinematically excited vibrations. Rayleigh method of determining approximate eigen-frequencies of continuous systems.

6. Analysis of vibrations of nonlinear systems (4 hrs)
Linearization methods. Galerkin method. Properties of nonlinear free vibrations. Damping with dry friction. Nonlinear vibrations under harmonic excitation. Resonance in nonlinear systems.

7. Linear parametric equations (2 hrs)
Nature and technical importance of parametric vibrations. Hill and Mathieu equations. Phenomenon of parametric resonance. Solution of Mathieu equation..

Class exercises
1. Harmonic analysis and synthesis. Spectrum of periodic vibrations.
2. Solving problems of free vibrations of systems with single degree of freedom.
3. Calculations of amplitudes of harmonically excited vibrations. Resonant curves in case of unbalance and kinematical excitations.
4. Interpretation of vibrations on the phase plane. Singular points and sketching phase portraits of linear and nonlinear systems.
5. Analysis of free vibrations of systems with two degrees of freedom. Natural frequencies and eigen-form coefficients.
6. Harmonically forced vibrations. Resonant curves. Dynamic vibration absorber.

**Metody oceny:**

Class exercises: written tests on practical ability to solve simple problems as examples of theory presented within the lecture. Attestation of class exercises. Lecture: written examination on skills and knowledge concerning the scope of the course.

**Egzamin:**

tak

**Literatura:**

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**Witryna www przedmiotu:**

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**Uwagi:**

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## Efekty przedmiotowe