**Nazwa przedmiotu:**

Mechanics of Structures 2

**Koordynator przedmiotu:**

prof. dr hab. inż. Tomasz Lewiński, dr hab. inż. Grzegorz Dzierżanowski, prof. PW

**Status przedmiotu:**

Obowiązkowy

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Civil Engineering

**Grupa przedmiotów:**

Obligatory

**Kod przedmiotu:**

1080-BU000-ISA-0405

**Semestr nominalny:**

6 / rok ak. 2021/2022

**Liczba punktów ECTS:**

5

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

Computing the ECTS credits: the lecture: 30, the classes :15, the design course: 15, preparing to the course: 10; preparing to the colloquia:10; preparing the homeworks: 25, preparing to the exam and the time of the exam: 20; the sum: 125 hours=5 ECTS

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

The lecture: 30; the classes: 15, the design course: 15, preparing to the colloquia: 10, defences of the homeworks: 10; the sum: 80 hours=3 ECTS

**Język prowadzenia zajęć:**

angielski

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

Preparing homeworks: 25; practical training during the classes: 30; the sum: 55= 2 ECTS

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

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

**Wymagania wstępne:**

Matrix equations. Cramer's systems with quadratic matrices. Eigenvalue problems with one (standard) and two symmetric matrices. Positive definiteness of quadratic forms. Elementary skills from the mathematical analysis: differentiation and integration of elementary functions. The definite integral. Skills in solving the ordinary differential equations of constant coefficients. The variational form of these equations. Setting the relevant boundary value and initial value problems. Understanding the fundamental laws of Theoretical Mechanics concerning bar structures in plane and space. Setting the equations of motion of material points and rigid bodies. Equations of motion of systems with constraints - Lagrange equations. The courses required: Strength of Materials I, Mechanics of Structures 1. The admittance to the exam of MoS2 is conditioned by receiving an affirmative joint grade for Mechanics of Structures 1.

**Limit liczby studentów:**

according to the Dean's decision

**Cel przedmiotu:**

Skills in solving the plane equilibrium problems of frames subject to large axial loadings. Computing the stress resultants, displacements and angles of rotations of the cross sections. Skills in computing the buckling loads for plane frames. Skills in analysis of dynamical response of elastic systems with one degree of freedom. Undamped and damped vibrations caused by arbitrarily varying loadings. Ability to set and solve the vibration problems of systems with lumped masses and finite number of degrees of freedom: undamped vibrations under arbitrary loading. Eigenvibrations of systems of discrete distribution of mass and finite number of degrees of freedom. Skills in analysis of natural and harmonic vibrations of plane frames made from incompressible bars.

**Treści kształcenia:**

Theory of equilibrium of plane frames subject to large axial loads. The displacement method in its enhanced form. Buckling of frames. The safety domains for independent multiple axial loadings. Theory of undamped and damped vibrations of systems of one degree of freedom. Arbitrary loading case - Duhamel's integral. The resonance diagram. The phase shift versus the damping level. Dynamical analysis of elastic systems of discrete distribution of mass and finite number of degrees of freedom. The forced harmonic vibrations. Analysis of displacements of masses depending on the enforced frequency values. Natural vibrations modes. Orthogonality of the natural modes (with mass weights). The normal coordinates and the mode-superposition procedure. The undamped vibrations caused by arbitrary loadings. Theory of flexural vibrations of elastic bars. Eigenmode analysis and harmonic vibrations of frames of incompressible bars of continuous distribution of mass. The displacement method in terms of amplitudes of generalized displacements and stress resultants for plane frames of incompressible bars.

**Metody oceny:**

The method of evaluation consists in the in-semester tests, homework projects and written as well as oral exams

**Egzamin:**

tak

**Literatura:**

[1] CHOPRA, A.K., Dynamics of Structures. Theory and Applications to Earthquake Engineering., New Jersey Prentice Hall, 2001 R.
[2] W.CLOUGH, J.PENZIEN, Dynamics of Structures. Mc Graw Hill, NY, 1975.
[3] Teaching materials available from the website.
[4] Nick Trahair, Flexural-Torsional Buckling of Structures, Taylor & Francis 1993.

**Witryna www przedmiotu:**

https://pele.il.pw.edu.pl/moodle/course/view.php?id=360

**Uwagi:**

## Charakterystyki przedmiotowe

### Profil ogólnoakademicki - wiedza

**Charakterystyka W1:**

Students know the theory of plane statically indeterminate bar systems subjected to big axial forces. They know the displacement method in the version taking into account the effect of big axial forces. They know the theory of buckling of frames and the idea of a safety domain corresponding to multiple load cases. Students learn the theory of vibrations of undamped and damped systems of a single degree of freedom. They know how to handle an arbitrary dynamic load and how to make use of Duhamel integrals. They learn how to interpret the resonance diagrams. They learn how to analyze vibrations of systems of discretized mass distribution and of finite number of degrees of freedom. They know how to analyze structural response to harmonic loads. They understand the meaning of free vibrations. They learn about orthogonality of eigenvibrations (with mass weights). They learn how to handle loads of arbitrary variation in time. They learn the theory of flexural vibrations of bars and frames of inextensible bars. They learn the specific version of the displacement method aimed at computing amplitudes of stress resultants in frames subject to harmonic loads.

Weryfikacja:

3 colloquia, 3 homeworks along with their defences; the written and oral exams.

**Powiązane charakterystyki kierunkowe:** K1\_W01, K1\_W04, K1\_W07

**Powiązane charakterystyki obszarowe:** P6U\_W, I.P6S\_WG.o

### Profil ogólnoakademicki - umiejętności

**Charakterystyka U1:**

Within the framework of the problems of bar systems subject to big axial forces the students acquire knowledge in: solving the static problems of plane frames subject to big axial forces and simultaneously bent-finding diagrams of internal forces, displacements, rotations of nodes; computing the buckling forces of bar systems; construction of safety domains for multiple load cases. In the domain of structural dynamics the students learn the skills in: dynamic analysis of elastic systems of a single degree of freedom, under arbitrary excitation in both: undamped and damped cases; dynamic analysis of bar systems of finite number of degrees of freedom and of lumped mass distribution: undamped vibrations due to arbitrary loading in time. Students learn how to analyse the eigenvibrations of systems of finite number of degrees of freedom. They learn how to analyze harmonic vibrations of plane frames of inextensible bars.

Weryfikacja:

3 colloquia, 3 homeworks along with their defences; the written and oral exams.

**Powiązane charakterystyki kierunkowe:** K1\_U07, K1\_U09, K1\_U19, K1\_U03, K1\_U04, K1\_U05, K1\_U06

**Powiązane charakterystyki obszarowe:** P6U\_U, I.P6S\_UW.o, III.P6S\_UW.o, I.P6S\_UK

**Charakterystyka U2:**

Korzystając z poleconej literatury przedmiotu potrafi samodzielnie przygotowywać prace domowe. Potrafi się przygotować do obrony pracy domowej.

Weryfikacja:

The defence of the homework

**Powiązane charakterystyki kierunkowe:** K1\_U23, K1\_U20, K1\_U19

**Powiązane charakterystyki obszarowe:** P6U\_U, I.P6S\_UO, I.P6S\_UU, I.P6S\_UK

### Profil ogólnoakademicki - kompetencje społeczne

**Charakterystyka K1:**

Students cooperate with each other; they learn how to work together as a team. They understand the importance of the responsibility in the engineering activity and of the professionalism in presenting the results of their work. Student become aware of necessity of accurate and precise analyses of the engineering problems, being informed of consequences of misinterpretations of the structures response.

Weryfikacja:

Assessment of the students' activity during classes and team works.

**Powiązane charakterystyki kierunkowe:** K1\_K01, K1\_K02, K1\_K07, K1\_K08

**Powiązane charakterystyki obszarowe:** P6U\_K, I.P6S\_KR, I.P6S\_KK