COURSE DESCRIPTION CARD - SYLLABUS

Course name
Strength Analysis of Mechanical Structures

Course

Field of study
Mechatronics
Area of study (specialization)

Level of study
Second-cycle studies
Form of study
full-time

Year/Semester
1/1
Profile of study
general academic
Course offered in
Polish
Requirements
compulsory

Number of hours

Lecture
15
Laboratory classes
15
Other (e.g. online)

Tutorials
15
Projects/seminars

Number of credit points

4

Lecturers

Responsible for the course/lecturer:
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Faculty of Mechanical Engineering
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Responsible for the course/lecturer:

Prerequisites

Student should have basic knowledge of mathematics, mechanics, strength of materials and material science. Should know how to apply the knowledge from geometry, trigonometry and calculus to model problems related to the mechanics of structures.

Course objective

The subject aims at presenting the application of basic engineering knowledge from the first-cycle study to solve complex problems in the field of analysis of structures and at broaden the knowledge on new issuses and methods used in the fields of machine elements design. The relations between different engineering areas which appear during the design process of machine elements are emphasized.

Course-related learning outcomes

Knowledge

1. Has extended and well-founded knowledge in engineering applications of mathematics, in particular differential equations, integration, trigonometric functions to model engineering problems.
2. Has knowledge in strength analyses of selected structural elements and know the relation between the strength and stiffness condition and reliability of structures.
3. Has basic knowledge in strength analyses of simple elements under dynamic load and understand the influence of this load on structural behavior.
4. Has knowledge about describing the field of displacement and the state of stress in selected structural elements.

Skills

1. Knows how to retrieve information from literature, databases and other properly selected sources in the area of strenght analysis of structures.
2. Knows how to prepare a brief scientific report in English to present results of his/her own research.
3. Knows how to apply mathematics in basic analysis of structural elements and in mathematical modeling of behavior of structures.
4. Knows how to carry out strength calculations to determine reliability of selected mechanical construction.

Social competences

1. Is aware of the importance of non-technical aspects and results of engineering activities including its influence on the environment involving responsibility for decisions taken.
2. Understands the impact of the designer's work on the functioning and shaping of society.
3. Understands the complexity of the design process and the necessity of the team work to realize the process.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:

- project, carried out in pairs, covering knowledge from the lectures; a hard copy of the project must be presented to the lecturer

Tutorial:

- two test lasting about 90 min. containing one or two problems to solve; the problems cover the subjects presented during the tutorials; about 60% of poits are necessary to pass the test

Laboratory:
- preparation of raports on all performed exercises
- current knowledge checking necessary to perform the exercise

Programme content

Lecture:
1. Introduction
- introduction of basic concepts in strength analysis; getting acquainted with tools and methods of the analysis of structures

2.Application of energy methods in mechanics
- definition of energy of elastic deformation; Castigliano's theorem; displacements in bars and frames

3. Curved bars
- forces and displacements in curved bars; stress distribution in highly curved bars; influence of local plasticization

4. Impact load
- principle of stationary total potential energy; impact factor; influence of the impact parameters on the stress distribution; design of elements loaded with dynamic load; absorption of impact energy

5. Axially symmetrical problems - thick-walled cylinders and rotating discs
- Lame's equations - stress distribution in thick-walled tubes and rotating discs; strains and stress in cylindrical coordinate system; press fit connection; design of multi-layered thick-walled cylinders - layer optimization with respect to stress distribution; design of rotating discs of equal strength

6. Thin-walled tanks
- characteristics of thin-walled structures; membrane state of stress; stress distribution in selected axially symmetrical thin-walled tanks

Tutorial:
- analysis of displacements in bar structures; stress analysis in curved bars and thick-walled elements; stress analysis of structural components subjected to dynamic load

Laboratory:
1. Stress-concentration factor in a flat bar with cut-out - FEM analysis

2. Modelling of sandwich beams - determining mechanical properties of the meterial; solving the three-point bending problem with the use of analytical and numerical method and comparison of the results with the experiment

3. Buckling of a slender bar - comparison of the results of buckling analysis of a bar obtained with analytical and numerical methods with the results of the experiment

4. Strength analysis of a permenent joint - analytical solution; tensile test on the testing machine; FEM modelling

5. Analysis of stress distribution in the press-fit connection - analytical description of stress distribution (Lame's equations); modelling of the press-fit connection with the use of FEM

6. Numerical analysis of stress distribution and deformation of a rotating element - drone propeller blade

Teaching methods

Lectures:
- lecture with multimedia presentation containing figures and pictures supported with examples presented on the blackboard
- the theory is presented in close relation with practice
- different aspects of presented problems are included e.g. economic, ecological, social, etc.
- during the lecture the discussion with students is initiated

Tutorials:
- solving exemplary problems on the blackboard
- tutorials are complemented with multimedia presentations containing figures and pictures
- the discussion is initiated on the obtained solutions of presented problems

Laboratory:
- discussion of issues related to the laboratory exercises
- carrying out of investigations and measurements as well as numerical analyses
- discussion on the prepared reports from the experiments

Bibliography

Basic

1. Dyląg Z., Jakubowicz A., Orłoś Z. Wytrzymałość materiałów Tom I i II, WNT, Warszawa, 1997
2. Ostwald M. Podstawy wytrzymałości materiałów i konstrukcji, WPP, Poznań, 2017
3. Banasiak M., Grossman K, Trombski M. Zbiór zadań z wytrzymałości materiałów, PWN, Warszawa, 1998
4. Goodno BJ, Gere JM. Mechanics of materials, Cengage Learning, Boston, MA, 2018

Additional

1. Nash WA. Schaum’s Outline of Theory and Problems of Strength of Materials, McGraw-Hill, New York, 1998.
2. Hartog D. Advanced Strength of Materials, Dover Publications, Inc., New York, 1987
3. Boresi AP., Schmidt RJ. Advanced Mechanics of Materials, Joh Willey & Sons, Inc., New York, 2003
4. Juvinall RC. Engineering Considerations of Stress, Strain and Strength, , McGraw-Hill, New York, 1967.

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,0
Classes requiring direct contact with the teacher	45	2,0
Student's own work (literature studies, preparation of the project, preparation for tutorials, preparation for tests, preparation of reports from laboratory classes) [1]	55	2,0

[1] delete or add other activities as appropriate