# COURSE DESCRIPTION CARD - SYLLABUS

Course name

Mechanics

## Course

Field of study

Biomedical engineering

Area of study (specialization)

-

Level of study

First-cycle studies

Form of study

full-time

Year/Semester

1/2

Profile of study

general academic

Course offered in

English

Requirements

compulsory

## Number of hours

Lecture

30

Laboratory classes

15

Other (e.g. online)

0

Tutorials

15

Projects/seminars

0

## Number of credit points

4

## Lecturers

Responsible for the course/lecturer:

dr hab. inż. Grażyna Sypniewska-Kamińska

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Instytut Mechaniki Stosowanej

Wydział Inżynierii Mechanicznej

ul. Jana Pawła II 24, 60-965 Poznań

Responsible for the course/lecturer:

## Prerequisites

The student starting the course should have a basic knowledge in mathematics and physics at the first-cycle study level. He should have the ability to understand and interpret the acquired knowledge, and also to effective self-education and be ready to cooperate within a team.

## Course objective

Cognizing and understanding the main concepts and laws of mechanics. Developing skills in modeling of mechanical systems and in solving problems related to the movement and the equilibrium of the mechanical systems.

## Course-related learning outcomes

### Knowledge

1. The student who completed the course knows and is able to explain the main concepts in the area of engineering mechanics. He also knows the basic laws of mechanics and is able to write them using mathematical formulae and explain them in detail.

2. He has the knowledge in the field of engineering mechanics which allows for formulating and solving static and kinematic problems and formulating dynamic problems of mechanical systems.

### Skills

1. The student can formulate and solve the equilibrium equations.

2. He is able to make the structural analysis of simple multibody systems and determine the velocities and the accelerations of elements of these systems also.

3. He can derive the equations of motion of the particle, formulate the appropriate initial conditions and to solve the problem.

4. He can formulate the laws related to change of the momentum and the angular momentum for free and constrained mechanical systems.

### Social competences

1. The student understands the importance of knowledge in the modern world. He is also well aware that the rapid development of knowledge causes the need for lifelong learning.

2. He is able to think and act in a creative way.

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lectures: Exam in writing involving practical and theoretical issues. The exam tasks are rated on a point scale. 50% of the total points is needed to pass the exam.

Tutorials: Tests in written and assessment of the activity on classes. Both assessment components are rated on a point scale. To pass the classes the student needs at least 50% of total points.

Laboratory classes: assessment of self-solved problems using Mathematica program. Credit for a positive grade after obtaining at least 50% of the total points..

## Programme content

Lectures: Material particle and rigid body. Reference frame. Vector calculus in mechanics. Introduction to statics and dynamics - modelling of mechanical interactions, basic knowledge about forces, the moment of a force about a point, the moment of a force about an axis. Force systems – the resultant force and the resultant moment, equivalent force systems, the couple, reduction of an arbitrary force system, special cases of the reduction of force system, the force resultant. Statics - the axioms of statics, the equilibrium equations for any spatial force system, the equilibrium conditions for the system of parallel forces, the equilibrium conditions for the concurrent system of forces, the equilibrium conditions for the plane system of forces. Supports and their reaction forces. Statics of multi-body systems. The laws of friction force, the equilibrium in the case of the friction forces action. Kinematics of a particle – the kinematic equations of motion, the particle motion path, the displacement of the point, the velocity vector, the acceleration vector. Description of the particle motion in the Cartesian coordinate system and in the cylindrical coordinates systems. Description of the point motion in the natural coordinate system (the Frenet coordinate system). Kinematics of a rigid body – the rigid body constraints, the theorem about the projections of the velocity vectors of two rigid body points, the degrees of freedom, the moving reference system and the fixed reference system, the kinematic equations of motion of the rigid body, time derivatives of the unit vectors of the moving reference system, the angular velocity vector and the angular acceleration vector, the velocity and acceleration of any point of the rigid body. The translational motion, the rotational motion and the plane motion of the rigid body. The instantaneous centre of rotation. Dynamics of a particle – the Newton laws of motion, direct and inverse problems of dynamics, the initial conditions and the initial value problems of dynamics of a particle. Dynamics of mechanical system – free and constrained mechanical systems. The momentum of a particle, the momentum of particles system, the momentum of a rigid body. The angular momentum of a particle, the angular momentum of particles system, the angular momentum of a rigid body. The relation between the momentum and the velocity of the mass centre. The relation between the angular momentum with respect to any point and with respect to the mass centre. The kinetic energy of a mechanical system. The Koenig theorem about kinetic energy for a system of particles and for a rigid body. The laws related to change of the momentum and the angular momentum for free and constrained mechanical systems. The work of a force. Potential and conservative forces. The potential energy. The work-energy theorem. The principle of conservation of the mechanical energy.

Tutorials: Mass distribution, mass center. Statics. The equilibrium equations for any spatial force system and the plane system of forces. Equilibrium of multi-body systems. Kinematics of a particle – analysis of the particle motion on the basis of the kinematic equations in the Cartesian coordinate system. Derivation of the kinematic equations of motion for selected points of mechanical systems. Kinematics of the plane motion of chosen mechanisms – determination of the velocities and the accelerations of points and the angular velocities and angular accelerations of the mechanism members. Dynamics of a material particle.

Laboratory classes: Short introduction to Mathematica program. Elements of vector calculus. Mass distribution, moments and products of inertia, tensor of inertia. The Steiner theorem about parallel axes. The Cartesian coordinate system rotation. Rotation matrix. Inertia tensor transformation at rotation of the coordinate system. Equilibrium of any spatial force system. Kinematics of a particle – analysis of the particle motion on the basis of the kinematic equations in the Cartesian coordinate system. Modeling and solving inverse problems of particle dynamics.

## Teaching methods

Lectures: lecture supported by multimedia presentations, solving tasks on the blackboard. Presentations and issues that help students prepare for the exam are available online on the Moodle platform.

Tutorials: problem solving, discussion. A course supporting classes is available on the Moodle platform, containing solutions to tasks with broad comments and proposals for tasks for self learning.

Laboratory classes: solving problems with the use of Mathematica enabling the presentation of results in graphic form and the animation of motion. Discussion of results.

## Bibliography

Basic

1. Z. Osiński, Mechanika ogólna, PWN.

2. J. Leyko, Mechanika ogólna t. 1-2, PWN.

3. M. Łunc, A. Szaniawski, Zarys mechaniki ogólnej, PWN.

4. Misiak J., Zadania z mechaniki ogólnej, WNT, Warszawa.

Additional

1. J. R. Taylor, Mechanika klasyczna, t. 1 - 2, PWN.

2. W. Szcześniak, Mechanika klasyczna, analityczna i Mathematica w zadaniach i przykładach obliczeniowych, OWPW, Warszawa.

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 100 | 4,0 |
| Classes requiring direct contact with the teacher | 62 | 2,5 |
| Student's own work (literature studies, preparation for tutorials and laboratory classes, preparation and analysis of laboratory results, preparation for tests and for the exam) [1] | 38 | 1,5 |

[1] delete or add other activities as appropriate