POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Mechanics and mechatronics [S1Eltech1>MiM1]

Course

Field of study
Electrical Engineering

Year/Semester
2/3

Area of study (specialization)
–

Profile of study
practical

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
15

Number of credit points

2,00

Coordinators

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Lecturers

Prerequisites

The student starting the course should have a basic knowledge in mathematics and physics in the field of the first-cycle study. He should also have the ability to understand and interpret the cognizance learned, 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 mechanical systems being parts of mechatronic systems and in solving problems related to the movement and the equilibrium of 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 simple static and kinematic problems and formulating dynamic problems of mechanical systems.

3. He knows and is able to explain the simplified models applied in engineering practice.
4. He has the knowledge of mechanics necessary to understand the basic physical phenomena occurring in mechatronic systems.

Skills:
1. The student can formulate and solve the equilibrium equations. 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.
2. He can derive the equations of motion of the particle and formulate the appropriate initial conditions. He can also formulate the laws related to change of momentum and 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, and working in a group also stimulates the development of social skills.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
1. Lectures: Written test conducted at the last lecture. The test consists of 4 questions about theoretical issues and two practical tasks. The pass threshold equals 50% of the total points. A list of issues on the basis of which questions and tasks are developed is made available to students in the electronic form.
2. The project classes: Credit based on the total number of points gained during the semester. The pass threshold equals 50% of the total points. Points are awarded for:
- an effective participation at the classes - the level of advancement of the solution of the problem is assessed,
- the documentation of the project - the knowledge and the skills necessary for the implementation of a given project and the ability to clearly present the results of work are evaluated. The score is awarded to the team making the project,
- test of a practical nature conducted at the last classes.

Programme content

Subject of mechanics and mechatronics. Mechatronic systems.
Elements of vector calculus.
Introduction to statics and dynamics - a force as a model of interactions between bodies.
Systems of forces. Equivalent force systems. The force-and-couple resultant of a system of forces.
Statics. Equations of equilibrium. Constrained material systems. Constraints. Equilibrium of a system of interacting bodies.
Kinematics of a particle. Description of the motion of a particle in the Cartesian coordinate system. Description of the point motion in the natural coordinate system.
Kinematics of a rigid body. General motion of a rigid body. Translational motion, rotational motion and plane motion of a rigid body.
Dynamics of a material particle. Direct and inverse problems of the dynamics of a material particle.
Dynamics of a free and constrained material systems. Momentum, angular momentum, and kinetic energy.
Inertia properties of material systems. Inertia tensor. Dynamics of a rigid body.

Course topics

Lectures: Subject of mechanics and mechatronics. Mechatronic devices. Role of mechanical systems in mechatronic systems.
Movement. Reference frame. Material particle and rigid body as models of real bodies in engineering mechanics.
A force as a model of interactions between bodies. Discrete and continuous forces. The density of linear forces. Newton's third law of motion. Axiom about the resultant force. Axiom about forces acting on rigid bodies. The moment of a force about a point. The moment of a force about an axis. Moments of a force about the axes of the Cartesian coordinate system.

A system of forces. Vector sum of forces and vector sum of moments of forces. The relation between sums of moments of a force system with respect to two different points. The parameter of a force system. The couple of forces. The moment of a couple of forces. Equivalent systems of forces. The force-and-couple resultant of a system of forces. Special force systems equivalent to a couple or to a single force. The force resultant.
Mechanical equilibrium. Static equilibrium. Equilibrium equations for an arbitrary system of forces. Equilibrium equations for a system of parallel forces. Equilibrium equations for a concurrent system of forces. Equilibrium equations for a coplanar system of forces. Constraints. The axiom about constraints. Supports and their reactions: cable, weightless link, frictionless pin, ball and socket joints, smooth and rough contact, pin supports, fixed support. Equilibrium of interacting bodies.
Basic concepts of kinematics of a point. Kinematic equations of motion in the vector form. The motion path of a point. Point displacement, velocity vector, acceleration vector. Description of the motion of a point in Cartesian coordinates. Axes and unit vectors of Frenet's coordinate system. The signed arc length coordinate. Description of the motion of a point in Cartesian coordinate. Tangential and normal components of the acceleration vector.
Kinematics of a rigid body. Rigid body constraints. Theorem on the projections of the velocity vectors of two rigid body points. Degrees of freedom of a free rigid body. Position of a rigid body with respect to immovable reference frame. Kinematic equations of motion of a free rigid body. Time derivatives of the unit vectors of the moving reference frame. The angular velocity vector and the angular acceleration vector. The velocity and acceleration of any point of the rigid body in general motion. Translational motion of a rigid body. Rotational motion of a rigid body – the kinematic equation of the rotational motion, angular velocity and angular acceleration, accelerated and retarded rotational movement, the velocity and acceleration of any point of the rigid body in the rotational motion, tangential and normal components of the acceleration vector. Plane motion of a rigid body - the kinematic equations of the plane motion, angular velocity and angular acceleration in the plane motion, the velocity and acceleration of any point of the rigid body in the plane motion. Velocity and acceleration vectors at the point of contact of a wheel rolling without slipping with the ground. Velocity and acceleration analysis for planar mechanisms.
Newton's laws of motion. Inertial frames of reference. Physical independence of forces. Newton's second law of motion for a constrained material particle. Direct and inverse problems of dynamics. Inverse problems of dynamics for a free and constrained material particle. Motion equations and initial conditions. Inverse problems of dynamics – formulation in the Cartesian coordinate system.
Free and constrained mechanical systems. The momentum of a particle, the momentum of a system of particles, the momentum of a rigid body. The momentum of a material system relative to the mass centre. The angular momentum of a particle, the angular momentum of a system of particles, the angular momentum of a rigid body. The angular momentum of a material system relative to the mass centre. The relation between the angular momentum with respect to any fixed point and with respect to the mass centre. The laws related to change of the momentum and the angular momentum for free and constrained mechanical systems (Euler's motion laws).
Inertia properties of material systems. First moments of inertia of a material system. The centre of mass. First moments of inertia of a material system with respect to the centre of mass. The mass moment of inertia. The products of inertia. The Cartesian tensor of inertia. The Cartesian tensor of inertia relative to the centre of mass. The principal axes of inertia. Parallel axis theorem. The angular momentum of a rigid body relative to the mass centre. Dynamic equations of motion for a rigid body.

Projects: Elements of vector calculus in the right-handed Cartesian coordinate system. Cartesian components of a vector. Decomposition of a vector into components using: a) the versor of the vector, b) the angles between the vector and the axes and planes of the Cartesian coordinate system. Moments of a force about the axes of the Cartesian coordinate system.
The equilibrium equations for the 3D system of concurrent forces. Determination of the forces in the rods of spatial trusses. Uniaxial normal stress. The Hooke law. Allowable stresses. Strength criterion for uniaxial tensile or compressive stresses.
The equilibrium equations for any spatial system of forces. Determination of the forces in the support rods. Uniaxial normal stress. The Hooke law. Allowable stresses. Strength criterion for uniaxial tensile or compressive stresses.
The equilibrium equations for a system of rigid bodies under action of the plane forces system. Static determinacy and geometric invariance of a planar system. The necessary and sufficient conditions for the geometrical invariance of the system. The resultant force for continuous linear forces. Determination of the reaction forces of and the forces at joints of the system.
Kinematics of a particle - determination of the particle trajectory, velocity and acceleration of the particle in the Cartesian coordinate system and in the natural system of the trajectory (the Frenet frame).

Structural analysis and kinematics of multibody systems in plane motion. Determination of velocity and acceleration vectors of chosen points of planar mechanisms. Determination of angular velocity and angular acceleration vectors of parts of planar mechanisms.
Application of the systems performing symbolic-numerical calculations (MatLab, Mathematica, wxMaxima) in engineering calculations.

Teaching methods

1. The lectures assisted by multimedial presentations and problem solving at the board. The students receive the lecture outline containing drawings, basic formulae and contents of the tasks (the outline is provided in the electronic form).
2. The project classes consists of four parts:
- a brief theoretical introduction,
- solving the exemplary problem by the teacher at the board,
- solving the project tasks in two-person teams. Each group solves a different problem. The lecturer consults the problems with the teams.
- an evaluation (by the lecturer) of the current achievements.

Bibliography

Basic
1. Leyko J., Mechanika ogólna, tom I i II, PWN, Warszawa 2013.
2. Osiński Z., Mechanika ogólna, PWN, Warszawa 2000.
3. Misiak J., Zadania z mechaniki ogólnej, część 1 i 2, WNT, Warszawa, 2012.
Additional
1.Taylor J.R., Mechanika klasyczna, t. 1 - 2, PWN, Warszawa 2012.
2. Misiak J., Mechanika techniczna, tom I i II, WNT, Warszawa, 1996.
3. Nizioł J., Metodyka rozwiązywania zadań z mechaniki, WNT, Warszawa, 2007.

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	40	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	10	0,00