**Nazwa przedmiotu:**

Theoretical Mechanics I

**Koordynator przedmiotu:**

Prof. Piotr Przybyłowicz, PhD, DSc

**Status przedmiotu:**

Obowiązkowy

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Electric and Hybrid Vehicles Engineering

**Grupa przedmiotów:**

Fizyka i Mechanika

**Kod przedmiotu:**

1150-00000-ISA-0118

**Semestr nominalny:**

2 / rok ak. 2022/2023

**Liczba punktów ECTS:**

5

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

1) Number of hours with direct contact with the teacher: 65 hrs, including
- lecture: 30 hrs
- practical classes: 30 hrs
- consultations: 5 hrs

2) Student's own work: 60 hrs, including
- ongoing preparation for excercises: 30 hrs
- literature studies and current preparation for tests: 15 hrs
- preparation for the exam: 15 hrs

3) TOTAL number of hours: 125.

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

2.6 ECTS
Number of hours with direct contact with the teacher: 65 hrs, including
- lecture: 30 hrs
- practical classes: 30 hrs
- consultations: 5 hrs

**Język prowadzenia zajęć:**

angielski

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

2.4 ECTS
60 hours of student's work, including
- participation in the practical classes: 30 hrs
- indepedent solving of practical problems at home: 7.5 hrs
- preparation for tests: 7.5 hrs
- preparation for the exam: 15 hrs

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

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

**Wymagania wstępne:**

Recommended formal attestation of the course of Mathematics prior to Theoretical Mechanics I.
Knowledge in linear algebra and differential calculus.

**Limit liczby studentów:**

Brak

**Cel przedmiotu:**

Understanding Mechanics as a knowledge on motion of particles, bodies, mechanisms, machines and vehicles. Formulation of basic laws of motion and state of rest of bodies and multi-body systems. Understanding the nature and types of mechanical actions - forces and moments. Modeling of mechanical systems for the technical purposes. Geometrical conditions of equilibrium of a body and mechanical system. Important phenomena in mechanics related to dry friction. Understanding velocity and acceleration as vector functions of time. Ability to analyze motion of a particle under forces dependent on position, velocity and time. The role of internal forces in multi-body systems. Kinetic energy of a particle and multi-particle systems and its variations during motion.

**Treści kształcenia:**

Lecture:

1. Introduction
Subject of Mechanics. Internal classification of Mechanics. Historical outline. Mechanics as a theory. Basic notions, Newton’s laws. Parts of Theoretical Mechanics. SI units in Mechanics.

2. Vectors and vector calculus
Scalars and vectors in Mechanics. Geometric and analytic description of vectors. Vector calculus. Vector functions of time.

3. Geometry of mass
First moments of particles and bodies. Mass centers and centroids of bodies and figures. Pappus-Guldinus rules. Second moments of particles and bodies - moments of inertia and product moments. Inertia matrix of a body. Transformation rules. Principal axes and principal moments of inertia of a body. Ellipsoid of inertia of a body.

4. Statics of particles, bodies and multi-body systems
Models of rigid bodies. Classification of forces. Types of supports. Problems and methods in Statics. Resultant of mechanical actions on a body. Wrench and resultant force. Geometric and analytical conditions of equilibrium. Dry friction and its effects in Statics. Plane trusses.

5. Kinematics of a particle
Geometric and analytical description of motion of a particle. Trajectory of motion. Velocity and acceleration of a particle in Cartesian and cylindrical/polar coordinate systems. Natural directions of motion. Moving trihedral. Tangent and normal accelerations. Special cases: uniformly variable motion, harmonic motion, motion in a central field of acceleration.

6. Dynamics of a particle
Equations of motion of a free and constrained particle. Motion of a particle under force dependent on time, position and velocity. Resistance of dry friction. Resistance dependent on velocity of motion. Momentum law. Angular momentum law. Work and power of a force. Kinetic energy law. Dynamics of a particle under potential force. Potential energy. Principle of mechanical energy conservation. Newton’s law of gravitation. Escape velocity.

7. Dynamics of multi-particle systems
Equations of motion. Constraints and their reactions. Momentum law. Angular momentum law. Kinetic energy law. Principle of mechanical energy conservation.

Class exercises:

1. Calculations of mass center positions and moments of inertia of bodies.
2. Solving problems of statics without friction – positions of equilibrium and reactions of supports of bodies and mechanisms.
3. Solving problems of statics with dry friction – phenomena of self-locking and jamming, duality of loss of equilibrium, belt friction, resistance to rolling.
4. Calculations of velocities and accelerations in various reference systems.
5. Analysis of motion of a free particle under force dependent on position, velocity and time. Application of linear momentum law and angular momentum law for a particle. Making use of kinetic energy law and principle of conservation of energy in the case of a particle.
6. Application of linear momentum law in case of a multi-particle system. Law of motion of mass center. The role of internal forces in changes of the linear momentum and energy.

**Metody oceny:**

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

**Egzamin:**

tak

**Literatura:**

W. Kurnik, Theoretical Mechanics I, Prescript available for students on Faculty website

**Witryna www przedmiotu:**

Brak

**Uwagi:**

## Efekty przedmiotowe

### Profil ogólnoakademicki - wiedza

**Efekt 1150-00000-ISA-0118\_W01:**

The student knows fundamental quantities observed in mechanics such as force, mass, torque relative to a point, velocity, acceleration, angular velocity and acceleration, momentum, angular momentum, kinetic and potential Energy; knows their physical units and significance.

Weryfikacja:

Written and oral exam

**Powiązane efekty kierunkowe:** K\_W01, K\_W02, K\_W03

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W01, T1A\_W02

**Efekt 1150-00000-ISA-0118\_W02:**

knows fundamental methods applied in general mechanics and knows which method should be selected to a given problem.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_W01, K\_W02, K\_W03

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W01, T1A\_W02

**Efekt 1150-00000-ISA-0118\_W03:**

is able to explain phenomena of practical significance in mechanics and mechanisms related to motion of mechanical systems including self-locking, seizure, duality in the loss of an equilibrium state, statical indeterminacy, motion resistance, conservation of motion of centroids, free falling in the gravity field, energy conservation law.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_W01, K\_W02, K\_W03

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W01, T1A\_W02

**Efekt 1150-00000-ISA-0118\_W04:**

understands cause-effect relationships in mechanics expressed in terms of laws of mechanics (equilibrium conditions, conservation laws) and possesses basic knowledge enabling making use of these laws in practical problems.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_W01, K\_W02, K\_W03

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W01, T1A\_W02

**Efekt 1150-00000-ISA-0118\_W05:**

 knows how to build a physical model of a real mechanical system.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_W01, K\_W02, K\_W03

**Powiązane efekty obszarowe:** T1A\_W01, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W01, T1A\_W02

### Profil ogólnoakademicki - umiejętności

**Efekt 1150-00000-ISA-0118\_U01:**

The student can choose and apply and appropriate mechanical principle to solve the given problem.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0118\_U02:**

can evaluate correctness of the obtained results qualitatively and quantitatively.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0118\_U03:**

can determine position of the center of gravity in a system of particles and rigid bodies and can calculate moments of inertia through the parallel axes theorem.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0118\_U04:**

can reduce an arbitrary spatial system of forces to a wrench.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0118\_U05:**

can calculate reactions in supports of statically determinable two- and three-dimensional systems.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0118\_U06:**

 can solve problems in statics of systems with friction.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0118\_U07:**

can find velocity and acceleration of a particle in rectangular, polar and natural coordinate systems.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0118\_U08:**

can solve problems of projectiles moving in a uniform gravity field with resistant forces taken into account as well as particles moving vertically in a non-uniform field.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03

**Efekt 1150-00000-ISA-0118\_U09:**

can apply energy conservation law to a particle and a system of particles.

Weryfikacja:

Exam, written tests, evaluation of homework

**Powiązane efekty kierunkowe:** K\_U01, K\_U03

**Powiązane efekty obszarowe:** T1A\_U01, T1A\_U03