



JAGIELLONIAN
UNIVERSITY
IN KRAKÓW

Physics – Mechanical energy and thermodynamics

Educational subject description sheet

Basic information

Field of study Joint Bachelor in Sustainability		Education cycle 2025/26	
Speciality Economics, Management & Engineering		Subject code UJ.WPAJBSEMES.840.16633.25	
Organizational unit Faculty of Law and Administration		Lecture languages english	
Study level first cycle (joint degree programme)		Subject related to scientific research Yes	
Study form full-time degree programme		Disciplines Physical sciences	
Education profile General academic		ISCED classification 0533 Physics	
Mandatory obligatory		USOS code	
Subject coordinator	Piotr Szwedo		
Lecturer	Katja Lauri		
Period Semester 3	Examination exam	Number of ECTS points 4.0	
	Activities and hours Discussion class: 36		

Goals

C1	The student who completes the course knows how to model a physical system by recognizing interactions, writing the equations of motion, and solving it.
C2	The student understands the statistical description of entropy and temperature.
C3	The student knows heat transfer mechanisms.
C4	The student can analyze the behaviour of both kinetic and thermal systems also with the energy principle.
C5	The student will have an idea how physical principles can be applied in sustainability-related problems.

Subject's learning outcomes

Code	Outcomes in terms of	Effects	Examination methods
Knowledge - Student knows and understands:			
W1	Basic kinematic quantities and their intrinsic connections.	JBS_K1_W07	written exam
W2	The physical treatment of motion in general	JBS_K1_W07	written exam
W3	The four fundamental interactions and their roles.	JBS_K1_W07	written exam
W4	The intrinsic relationships between mass, velocity, momentum and force.	JBS_K1_W07	written exam
W5	The fundamentals of dynamics: Newton's first, second and third law.	JBS_K1_W07	written exam
W6	Fundamental forms of energy.	JBS_K1_W07	written exam
W7	Definition and role of work in physics.	JBS_K1_W07	written exam
W8	Differences between and implications of linear, circular and harmonic motion.	JBS_K1_W07	written exam
W9	Conservation of energy as a fundamental law.	JBS_K1_W07	written exam
W10	Conservation of mechanical energy in systems involving only conservative forces.	JBS_K1_W07	written exam
W11	Definition of power and efficiency.	JBS_K1_W06, JBS_K1_W07	written exam
W12	Treatment of gas molecules in kinetic gas theory.	JBS_K1_W07	written exam
W13	Connection between microstates and entropy.	JBS_K1_W07	written exam
W14	An atomic/molecular view at matter in different phases (solid, liquid, gas).	JBS_K1_W06	written exam
W15	The principle of heat engine, Carnot cycle.	JBS_K1_W06	written exam
W16	Equation of state, ideal gas law.	JBS_K1_W07	written exam
W17	Different views of temperature as a physical concept.	JBS_K1_W07	written exam
W18	Definition and role of heat in physics	JBS_K1_W06	written exam
W19	Definition of heat capacity	JBS_K1_W06	written exam
W20	First law of thermodynamics. Conservation of thermal energy in non-kinetic systems.	JBS_K1_W06	written exam

Code	Outcomes in terms of	Effects	Examination methods
W21	Second law of thermodynamics. Reversible and irreversible processes in terms of entropy.	JBS_K1_W06	written exam
W22	Concept of gradient in physics. Gradient as a driving force in transport phenomena.	JBS_K1_W06, JBS_K1_W07	written exam
W23	Basics of electromagnetic radiation. Planck's law. Blackbody radiation. Emissivity and absorptivity.	JBS_K1_W06, JBS_K1_W07	written exam
W24	Energy balance of a system (the Earth as an example).	JBS_K1_W06, JBS_K1_W07	written exam
W25	The possibilities and limitations of physical problem solving in sustainability challenges.	JBS_K1_W01	written exam
Skills - Student can:			
U1	qualitatively state the features of a projectile's motion	JBS_K1_U01	written exam
U2	derive kinematic quantities from each other in simple cases using calculus	JBS_K1_U01	written exam
U3	quantitatively forecast the motion of a body when the initial state of motion and forces are known.	JBS_K1_U01	written exam
U4	use the energy principle to quantitatively understand changes in kinetic systems.	JBS_K1_U01	written exam
U5	distinguish between conservative and non-conservative forces.	JBS_K1_U01	written exam
U6	Calculate power and efficiency in different kinds of systems.	JBS_K1_U01	written exam
U7	Qualitatively assess features of molecular motion and interactions in different phases (gas, liquid, solid).	JBS_K1_U01	written exam
U8	Use the concepts of work and heat in energy conversions, e.g. calculate energy conversion in a heat engine by integrating.	JBS_K1_U01	written exam
U9	Evaluate heat transfer of systems in steady state.	JBS_K1_U01	written exam
U10	Calculate the radiative power of a black body, e.g. a star.	JBS_K1_U01	written exam
Social competences - Student is ready for:			
K1	Contributing to solution of sustainability challenges from a physical perspective.	JBS_K1_K05	written exam

Calculation of ECTS points

Activity form	Activity hours*
Discussion class	36
preparation for classes	32
preparation for the exam	20
exercises performance	18

Student workload	Hours 106	ECTS 4.0
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* hour means 45 minutes

Study content

No.	Course content	Subject's learning outcomes
1.	Kinematics: position, displacement, velocity, acceleration, linear motion, motion of a projectile - part 1	W1, U1, U2
2.	Kinematics: position, displacement, velocity, acceleration, linear motion, motion of a projectile - part 2	W2, U1, U2
3.	Kinetics: definition of mass, force, fundamental interactions, Newton's laws (3h)	W3, W4, W5, U3
4.	Kinetic energy, potential energy, work, rest energy	W6, W7, U4
5.	Other forms of motion: harmonic motion, circular motion	W8, U3, U4
6.	Conservative forces, conservation of mechanical energy	W10, W9, U4, U5
7.	Power and efficiency	W11, U6
8.	Kinetic gas theory, brief introduction to statistical mechanics (3h)	W12, W13, W14, U7
9.	Introduction to fluid mechanics (def. of a fluid, pressure, heat engines and energy conversion in wind mills, hydraulic turbines, etc.)	W15, W16, U7
10.	Temperature, heat, heat capacity, thermal energy storage	W17, W18, W19, U8
11.	Laws of thermodynamics (conservation of energy, energy exchange and conversion) - part 1	W20, U8, U9
12.	Laws of thermodynamics (conservation of energy, energy exchange and conversion) - part 2	W21, U8, U9
13.	Heat transfer mechanisms (conduction, convection, radiation) - part 1	W22, U9
14.	Heat transfer mechanisms (conduction, convection, radiation) - part 2	W23, U9
15.	Applications (e.g. thermal insulation and comfort of buildings)	W24, U10
16.	Final workshop - connections to sustainability (4h)	W25, K1

Course advanced

Teaching methods :

conversation lecture, solving tasks, practicals

Activities	Examination methods	Credit conditions
Discussion class	written exam	Final exam accounts for 2/3 of course points. Weekly exercises account for 1/3 of course points

Entry requirements

None

Literature

Obligatory

1. Lecture notes and other material provided on the learning platform. Recommended supporting literature: Chabay & Sherwood: Matter & Interactions, 4th Edition (2015), John Wiley & Sons or Giancoli: Physics – Principles with Applications, 7th Edition (Global Edition, 2016), Pearson.

Effects

Code	Content
JBS_K1_K05	The graduate can defend the importance of scientific data and methods as a basis for decision-making.
JBS_K1_U01	The graduate can critically analyse academic literature, formulate research questions and conduct research under supervision.
JBS_K1_W01	The graduate can describe the concept of sustainability and recognize the differences in relevant definitions, models and approaches.
JBS_K1_W06	The graduate can describe interconnections between various aspects of sustainability and identify their significance in the context of natural and social sciences, with a special focus on disciplines included in the selected specialisation track (law and politics; chemistry and physics; chemistry and biology; economics and geography; economics, management and engineering; humanities).
JBS_K1_W07	The graduate can apply the theory and methodology of disciplines included in the selected specialisation track to sustainability-related problems, taking into consideration practical limitations such as protection of intellectual property.