National Technical University of Ukraine
«IGOR SIKORSKY KYIV
POLYTECHNIC INSTITUTE»

Department of General Physics and Modelling of Physical Processes

PHYSICS. PART 1. MECHANICS AND MOLECULAR PHYSICS

Working Program of the Academic Discipline (Syllabus)

Course Details

Level of higher education	***First (Bachelor's)***
Branch of knowledge	G Engineering, Manufacturing and Construction
Specialty	G7 Automation, Computer-Integrated Technologies and Robotics
Educational program	"Computer-Integrated Technologies and Robotics"
Course status	Mandatory (normative) (professional training cycle)
Form of study	Full-time (day)
Year of study, semester	1st year, autumn semester
Course workload	150 hours (5 ECTS credits): lectures – 30, practical classes – 16, laboratory classes – 14, self-study – 90.
Semester control / control measures	Exam, modular control work
Class schedule	The time and place of classes are published on the website https://schedule.kpi.ua
Language of instruction	Ukrainian
Information about the course leader / teachers	Lectures: Professor Oksana Gorobets, gorobets.oksana@gmail.com, Senior Lecturer Olha Kerita, o.kerita@kpi.ua Practical classes: Senior Lecturer Olha Kerita, o.kerita@kpi.ua, Assistant, PhD (Physics and Mathematics) Serhii Krasnovyd Laboratory classes: Assistant, PhD (Physics and Mathematics) Serhii Krasnovyd, sergkrasnovyd88@gmail.com, Assistant Nelia Ibrahimova, nelyaibrahimova18@gmail.com
Course placement	Link to the distance learning resource: https://do.ipo.kpi.ua/course/view.php?id=8074

Course Program

1. Course description, its aim, subject of study and learning outcomes

The physics course is the fundamental basis for studying a number of disciplines of professional and practical training of engineers in various fields. In the course "Physics", students will gain a thorough understanding of the laws of nature that underlie engineering decisions in solving production tasks.

Physics is one of the main natural science disciplines that study the laws of inanimate nature. Natural sciences today can be understood as those branches of knowledge in which an experiment can be carried out to confirm the assumptions and models put forward by theory. The evolution of the natural sciences has made it possible to significantly expand their research methodology compared with

philosophy, of which they were once a part, and to transform them from contemplative into experimental sciences.

In the classical physics course, students study the laws of nature that form the basis of the vast majority of engineering and technical disciplines, which are now independent fields of research and practice.

The aim of the course "Physics" is to provide future specialists with solid knowledge of the laws of nature and the ability to use this knowledge in the further study of specialized disciplines and in their future professional activity.

In particular, the aim of the credit module is to develop the following competences in students:

General competences

GC01. Ability to apply professional knowledge and skills in practical situations.

GC05. Ability to search for, process and analyse information from various sources.

GC08. Ability to learn and master modern knowledge.

Programme learning outcomes

PLO 11. To know and understand modern theoretical and experimental research methods, with assessment of the accuracy of the results obtained.

PLO 18. To be able to apply the knowledge gained in studying fundamental sciences when solving professional tasks.

The subject of the course "Physics" is the education and training of a specialist in the field of study G6 Information and Measurement Technologies.

After completing the course "Physics", the student should *know and be able* to use knowledge of the laws of inanimate nature at the level necessary to achieve other learning outcomes of the educational program, in particular those underlying the professional disciplines.

The student should *be able* to: combine theory and practice to solve practical tasks; apply the principles of systems analysis and of cause-and-effect relationships between significant factors and the scientific and technical decisions made when solving complex professional problems; find the necessary information in the literature, consult and use scientific databases and other relevant sources of information for detailed study and research of engineering issues according to their specialization.

To master the course successfully, the student should have a set of bachelor-level *competences*, in particular: the ability to apply knowledge and understanding of the scientific facts, concepts, theories, principles and methods needed to support an engineering specialization; the ability for abstract thinking, analysis and synthesis; the ability to make informed decisions; the ability to work individually; the ability to work in a team; the ability to use technical literature and other sources of information effectively; the ability to apply knowledge and understanding of the scientific facts, concepts, theories, principles and methods needed for successful work in their professional field.

The syllabus of the course "Physics" is based on the principle of constructive alignment, which makes it possible to anticipate the learning tasks and activities students need to achieve the expected learning outcomes and then to design the learning experience so as to maximise students' opportunities to achieve the desired results.

The syllabus is structured so that each subsequent task requires students to apply the skills and knowledge acquired in the previous one. The final stage is the exam, for which students use the theoretical knowledge and apply the practical skills acquired during all types of tasks (practical and laboratory classes) and through active participation in lectures (completing current tasks and activities). Particular attention is paid to the principle of encouraging active learning, according to which students work on practical thematic tasks that will allow them to solve real problems and tasks in the future.

Learning in practical and laboratory classes is based on a student-centred approach and a strategy of teacher–student interaction aimed at helping students master the material and develop practical skills.

Practical and laboratory classes use:

– active and collaborative learning strategies;

– personality-oriented developmental technologies based on active forms and methods of learning (team-based learning, think-pair-share, brainstorming, discussion, express conference, educational debates, etc.); – problem-based learning.

For a better understanding of the course structure and mastering of the material, the following communication services are used remotely: "Electronic Campus", Zoom, Telegram, the Moodle web environment at http://physics.zfftt.kpi.ua and e-mail, which help to:

– simplify the placement and exchange of learning materials;
– provide feedback to students on the course content and learning tasks;
– assess students' learning tasks;
– keep records of students' progress on the course plan, the schedule of learning tasks and student assessment.

In full-time study and for interaction with students, modern information, communication and network technologies are used to solve learning tasks, as well as equipment (a projector and electronic presentations for lectures).

The practical skills and theoretical knowledge acquired in the course "Physics" can be used later in the study of specialized disciplines.

2. Prerequisites and postrequisites of the course (place in the structural and logical scheme of training under the relevant educational program)

The course "Physics" is based on the knowledge of physics and mathematics acquired in general secondary education. The course involves the use of skills in the theory and technique of experiment and mathematical skills acquired in parallel study of mathematical disciplines. An essential element of the course is mastering the concepts and mathematical tools of mathematical analysis, analytic geometry, linear algebra and vector analysis. Some topics require the ability to solve simple differential equations.

The acquired knowledge and skills will be applied later in the study of both general technical and specialized disciplines. According to the structural and logical scheme, the postrequisites of the course are EC 9 "Electrical Devices of Information and Measurement Systems" and EC 10 "Theory of Electrical Signals and Circuits".

3. Course content

The course "Physics" consists of two content modules. In the first semester, the module "Physics. Part 1. Mechanics and Molecular Physics" is studied.

Content modules and topics	***Number of hours***				
		including			
	Total	***Lectures***	***Practical classes***	***Laboratory classes***	***Self-study***
1	2	3	4	5	6
Section 1. Physical foundations of mechanics					
Topic 1.1. Fundamentals of kinematics	20	4	3	2	10
Topic 1.2. Dynamics of translational motion	18	4	2	2	8
Topic 1.3. Conservation laws	14	4	2		8
Topic 1.4. Dynamics of rotational motion	29	7	2	4	14
Topic 1.5. Mechanical oscillations	9	2	1	2	4
Topic 1.6. Elements of the special theory of relativity	6	2			4
Total for Section 1	**96**	**22**	**10**	**10**	**48**
Section 2. Molecular physics and thermodynamics					
Topic 2.1. Fundamentals of thermodynamics	16	4	2	2	8
Topic 2.2. Fundamentals of molecular physics	32	4	4	2	16
Total for Section 2	**48**	**8**	**6**	**4**	**24**
Modular control work	**6**				**18**
Total hours	**150**	**30**	**16**	**14**	**90**

4. Educational materials and resources

RECOMMENDED LITERATURE

1. Kucheruk I. M., Horbachuk I. T., Lutsyk P. P. General Course of Physics. Vol. 1. – Kyiv: Tekhnika, 2006. (STL) [in Ukrainian]
2. Kucheruk I. M., Horbachuk I. T., Lutsyk P. P. General Course of Physics. Vol. 2. – Kyiv: Tekhnika, 2006. (STL) [in Ukrainian]
3. Kucheruk I. M., Horbachuk I. T., Lutsyk P. P. General Course of Physics. Vol. 3. – Kyiv: Tekhnika, 2006. (STL) [in Ukrainian]
4. Physics. Internet resource at URL: http://physics.zfftt.kpi.ua [in Ukrainian]
5. Laboratory Works in Physics. Internet resource at URL: http://physics.zfftt.kpi.ua/mod/page/view.php?id=540 [in Ukrainian]
6. General Course of Physics: Collection of Problems / I. P. Harkusha, I. T. Horbachuk, V. P. Kurinnyi et al. – Kyiv: Tekhnika, 2004. – 560 p. [in Ukrainian]

Educational Content

5. Methods of mastering the course (educational component)

LECTURES

No.	*Lecture topic and main issues (teaching materials, references and self-study assignments)*
1	Introduction. Physics as a science. Relationship between physics and related sciences. Physics and technological progress. The importance of fundamental education in physics and ways of obtaining it. Main branches of physics. Physical foundations of mechanics. Mechanics and its branches. Material point. Rigid body. Reference frames. Fundamentals of kinematics. The concepts of time and space.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
2	The concept of a vector in physics. The law of transformation of vector components under rotation of coordinate axes. Fundamentals of vector analysis. Vector addition. Scalar and vector products. Fundamentals of kinematics. Ways of describing motion. Equations of motion. Trajectory. Velocity and acceleration. Velocity and acceleration vectors.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
3	Fundamentals of kinematics. Normal and tangential acceleration. The mathematical concept of the curvature of a curve. Mean value of a function. Kinematics of rotational motion. Angular velocity and angular acceleration vectors. Relationship between linear and angular velocity in rotational motion.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
4	Dynamics of translational motion. Classical mechanics and the limits of its applicability. Newton's laws of dynamics. The concept of force. Characteristics of resistance and friction forces.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
5	Dynamics of translational motion. Elastic forces. Hooke's law. Fundamental forces. Fields. The law of universal gravitation. Coulomb's law. Inertial forces in non-inertial reference frames.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.

6	Conservation laws. The concepts of work and kinetic energy. The law of conservation of energy for a closed system of non-interacting particles. Conservative forces. Potential energy in an external force field. Relationship between force and potential energy. The law of conservation of total mechanical energy for a system of non-interacting particles in an external field of conservative forces.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
7	Conservation laws. Potential energy of interaction. The law of conservation of energy in a system of interacting particles in a field of external conservative forces. The law of conservation of momentum. The concept of the centre of mass.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
8	Dynamics of rotational motion. Two-dimensional rotation. The concepts of torque and angular momentum. The law of dynamics of two-dimensional rotational motion. The law of conservation of angular momentum for a system of particles.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
9	Dynamics of rotational motion. Rotation of a rigid body. The concept of moment of inertia. Properties of the centre of mass and moment of inertia. The parallel axis (Steiner) theorem. Kinetic energy of rotational motion.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
10	Dynamics of rotational motion. Inertial forces in a rotating reference frame. Centrifugal force. Coriolis force. Rotation in space. Torque and angular momentum vectors. The equation of rotational dynamics in vector form. Gyroscope. Precession.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
11	Oscillatory motion. General information. Free undamped oscillations. Energy of oscillatory motion. Simple and physical pendulums. Phasor diagram. Addition of oscillations in the same direction. Damped oscillations. Forced oscillations. Self-oscillations. Resonance.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
12	Molecular physics and thermodynamics. Thermodynamic and statistical methods for studying macrosystems. State of a system, processes. Fundamentals of thermodynamics. Internal energy; work done by a macrosystem. The first law of thermodynamics. The ideal gas equation of state. Heat capacity of an ideal gas at constant volume and constant pressure.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
13	Fundamentals of thermodynamics. Adiabatic process. Adiabatic equation. Polytropic processes. Heat capacity in a polytropic process. Work in a polytropic process. Fundamentals of molecular physics. Number of molecular impacts on a wall. Gas pressure on a wall. Mean kinetic energy of translational motion of molecules. The physical meaning of temperature. The hypothesis of equipartition of energy over degrees of freedom.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.

14	Fundamentals of probability theory. Random events. Probability. Addition and multiplication theorems of probability. Discrete random variables. Continuous random variables. Probability density. Distribution function. Mean values of random variables. Fluctuations.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.
15	The Maxwell distribution for velocity components and speed. Dependence of the distribution on temperature and molecular mass. Characteristic speeds.
Literature:	[1],[4]
Self-study:	Study of the lecture material. Problems.

PRACTICAL CLASSES

The main objective of the practical classes is for students to master techniques and methods for the practical application of knowledge.

To prepare for a practical class, the student should study the theoretical material on the topic. After the class, the student should complete the homework on problem solving.

No.	*Topic and main issues (teaching materials, references and self-study assignments)*
1	Vector quantities. Operations on vectors and their projections. Basic concepts and equations of the kinematics of a material point.
Literature:	[4],[6]
Self-study:	Problem solving. Worked examples. Problems for independent work.
2	Kinematics of curvilinear motion of a material point. Kinematics of rotational motion of a rigid body.
Literature:	[4],[6]
Self-study:	Problem solving. Worked examples. Problems for independent work.
3	Newton's laws of dynamics. Motion of a material point.
Literature:	[4],[6]
Self-study:	Problem solving. Worked examples. Problems for independent work.
4	Energy, work, power. The law of conservation of energy. Dynamics of a system of material points. The law of conservation of momentum.
Literature:	[4],[6]
Self-study:	Problem solving. Worked examples. Problems for independent work.
5	Dynamics of rotational motion of a rigid body.
Literature:	[4],[6]
Self-study:	Problem solving. Worked examples. Problems for independent work.
6	The law of conservation of angular momentum. Motion in non-inertial reference frames.
Literature:	[4],[6]
Self-study:	Problem solving. Worked examples. Problems for independent work.
7	The ideal gas equation of state. The first law of thermodynamics. Heat capacity of ideal gases.
Literature:	[4],[6]
Self-study:	Problem solving. Worked examples. Problems for independent work.
8	The Maxwell distribution. The Boltzmann distribution.
Literature:	[4],[6]
Self-study:	Problem solving. Worked examples. Problems for independent work.

LABORATORY CLASSES

In the first semester, students perform laboratory works from the "Mechanics" and "Molecular Physics and Thermodynamics" cycles according to the established schedule and timetable.

The main objective of the laboratory works is for students to gain experience in carrying out experimental research to verify theoretical statements and to learn the rules for processing experimental data and presenting the results.

To prepare for laboratory work, students should: 1) study the theory; 2) prepare the research protocol; 3) complete the virtual laboratory work; 4) pass a preliminary test to check their readiness for the laboratory work.

Each student performs 5 works from the list below (according to a schedule). The first class

No.	*Title of the laboratory work (computer practicum)*
1-1	Study of the theory of processing measurement results in a physics laboratory using a simple pendulum as an example.
1-2	Study of the laws of rigid body dynamics using a physical pendulum as an example.
1-3	Study of the laws of rotational dynamics using Oberbeck's pendulum.
1-4	Determination of the free-fall acceleration using a reversible pendulum.
1-5	Determination of the viscosity coefficient of a liquid by Stokes' method.
1-6	Determination of the ratio of the heat capacity of a gas at constant pressure to its heat capacity at constant volume.
1-7	Determination of the viscosity of air.
1-9	Study of the Boltzmann distribution.

6. Student's independent work

Self-study in the first semester amounts to 90 hours. It includes: studying the lecture material and individual theoretical topics assigned for independent study, preparing for practical classes, solving homework problems, preparing for laboratory works, preparing for the modular control work (MCW), writing the MCW and preparing for the exam.

The lecture material is studied regularly throughout the semester before the next lecture by reviewing the lecture notes and the recommended literature. This takes 30 to 60 minutes.

Preparation for practical classes involves reviewing or studying the relevant theoretical material and going through worked examples on the topic. This takes 1 to 2 hours.

Homework problems are solved to consolidate the knowledge and skills of applying the theory acquired in class. This takes 1 to 3 hours.

Preparation for laboratory works involves studying the laws of physics verified in the experiments, the research methodology, the measuring instruments used and the procedure for processing the experimental results. This takes 1 to 3 hours. After the laboratory work, students must present the results: perform the necessary calculations, plot graphs and calculate the errors. The processed experimental data must be submitted no later than the next laboratory class.

Preparation for the MCW involves revising the theory and its practical application. This takes 1 to 6 hours.

Policy and Control

7. Course policy (educational component)

Attendance at lectures, practical classes and laboratory works is mandatory. In case of illness, the student must submit a certificate of the period of treatment issued by the medical institution. In other cases (for example, family circumstances), the issue is resolved individually with the teacher. Attendance at lectures and practical classes, as well as absence from them, is not assessed. In any case, students are advised to attend all classes, since they present the theoretical material and develop the skills needed for current semester assignments, laboratory works and homework. The assessment system also provides for bonus points for activity in practical and laboratory classes.

The results of practical work are handwritten and accompanied by formulas and graphs that confirm the completion of the tasks and the results obtained.

In distance learning, practical work may be done by hand or in any text editor and may be submitted for checking in printed or electronic form. The defence takes the form of an interview with questions and answers.

During lectures, practical and laboratory classes, it is prohibited to use mobile phones for communication and unauthorised Internet searches. They may be used only for testing, for calculations in practical and laboratory classes and for measuring time in laboratory classes (if the smartphone has the appropriate software).

In distance learning, the lecturer uses their own presentation materials and Zoom and Google Meet for teaching and conducting practical classes.

Students are admitted to laboratory works if they: 1) have a protocol; 2) have passed the entry test. Students record the measurement results in the protocol and present them to the teacher for checking. Unchecked data are not accepted for defence. To defend a laboratory work, the student must answer the control questions and present the measurement results correctly (calculate the required quantities, plot the graphs according to the rules, calculate the errors, write down the final results with correct rounding and draw conclusions).

Homework is done in a separate notebook and submitted by the deadline set by the teacher at the beginning of the semester. Homework must be neat and legible.

Bonus points are awarded for active work in practical and laboratory classes and for participation in faculty and university physics olympiads. The number of bonus points per semester does not exceed 6.

The deadline policy requires timely completion of assignments. All written work must be submitted and defended before the end of the theoretical study period of the semester. Penalty points are given for late homework and late defence of laboratory works.

A student who misses the MCW without a valid reason receives a zero result. In this case, the student may write the MCW at a time set by the teacher, but the maximum score will be 50% of the total. Rewriting the MCW is not allowed.

All participants in the educational process, teachers and students, must follow the policy and principles of academic integrity defined by the Code of Honour of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More details: https://kpi.ua/code.

8. Types of control and the rating system for assessing learning outcomes (RSA)

The course rating takes into account the student's work during the semester and the level of knowledge and skills demonstrated at the exam. Students' work during the semester includes both classroom work and self-study. The course rating covers all types of work that students must complete during the semester under the rating system for assessing learning outcomes (RSA).

The course rating is formed as the sum of the points awarded to the student for:

- tasks in practical classes;
- homework on problem solving;
- laboratory works;
- the modular control work (MCW);
- exam tasks.

The course rating is formed as the sum of the points awarded to the student for:

- tasks in practical classes;
- homework on problem solving;
- laboratory works;
- the modular control work (MCW);
- exam tasks.

The course rating (R) is calculated as the sum of the points for current control during the semester (starting rating R_C) and the points received at the exam (R_E):

$$R = R_C + R_E .$$

The starting rating R_C is the sum of the rating points received for current control in practical classes (r_P), laboratory works (r_L) and the MCW (r_{MCW}):

$$R_C = \Sigma(r_P + r_L) + r_{MCW} .$$

The maximum starting rating is 50 points; the maximum number of points R_C received at the exam, R_E, is 50 points. The maximum total course rating for the semester R is 100 points.

The assessment criteria for work during the semester are given in Table 1, and bonus and penalty points in Table 2.

*In total, 6 laboratory works are performed during the semester; the maximum score for one laboratory work is 2.5 points.

The modular control work (MCW) is written. Each student receives an individual assignment.

Table 1. Assessment criteria for work during the semester.

No.	*Control measures*	*Maximum number of points*
1	Homework on problem solving	15
2	Modular control work	15
3	Laboratory works*	20
	Total	**50**

Table 2. Bonus and penalty points.

Criterion	*Maximum number of points*
Active work in practical and laboratory classes	5
Participation in faculty and university physics olympiads and physics competitions	5
Late homework on problem solving (one week late) Late submission of 1 homework assignment (one week late)	−5 −0.5
Late defence of laboratory works (one week late) Late defence of 1 laboratory work (one week late)	−5 −0.5
Maximum sum of penalty and bonus points	**−5...5**

Semester control: **exam**.

Students are admitted to the exam if they have scored at least 30 points in current control during the semester (starting rating R_C of at least 30 points), provided that all laboratory works and all homework assignments have been completed and the modular control work has a positive result (at least 60% of tasks done correctly). At the exam, a student can score up to 50 points.

Table 3. Exam assessment criteria.

Criterion	Number of points
The student demonstrates complete and deep knowledge of the material and can apply it correctly	45...50
The student demonstrates good knowledge of the material and can apply it correctly	30...45
The student demonstrates good knowledge of the material but makes some inaccuracies in applying it	25...35
The student demonstrates satisfactory knowledge of the material but makes significant inaccuracies in applying it	20...25

The student demonstrates satisfactory knowledge of the theory but makes significant errors in applying it	15…20
Unsatisfactory knowledge of the theory and lack of skills in solving the set tasks	1…15

The maximum total course rating for the semester is 100 points; the minimum positive total rating is 60 points.

The correspondence between rating points and grades on the university scale is given in Table 4.

Table 4. Correspondence between rating points and grades on the university scale.

Student's rating score	*University grading scale*
95…100	Excellent
85…94	Very good
75…84	Good
65…74	Satisfactory
60…64	Sufficient
Less than 60	Unsatisfactory
Admission conditions for semester control not met	Not admitted

9. Additional information on the course (educational component)

Inclusive education

The course "Physics" can be taught to most students with special educational needs, except for students with serious visual impairments that prevent them from completing tasks using personal computers, laptops and/or other technical means.

The lecturer reserves the right to change the order of presentation of the material and, in part, its volume and content, depending on students' learning abilities and capacity to master it.

Working program of the academic discipline (syllabus):
Physics. Part 1.
Mechanics and Molecular Physics

Compiled by Professor of the Department of General Physics and Modelling of Physical Processes Oksana Gorobets and Senior Lecturer of the Department Olha Kerita

Approved by the Department of General Physics and Modelling of Physical Processes (minutes No. 06-26 of 24.06.2026)

Agreed by the Methodical Commission of the Faculty of Robotics and Instrument Engineering (minutes No. 6/26 of 26.06.2026)