Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of General Physics

GENERAL PHYSICS 1

Work program of the academic discipline (Syllabus)

Course details	
Level of higher education	**First (bachelor's)**
Field of knowledge	G - Engineering, manufacturing, and construction
Specialty	G5 Electronics, electronic communications, instrument engineering, and radio engineering
Educational program	For all educational programs
Discipline status	Mandatory
Form of study	Full-time (day)
Year of study, semester	1st year, second semester
Scope of the discipline	240 hours (full-time: 60 hours – lectures, 30 hours – practical classes, 14 hours – laboratory work, 136 hours – independent study)
Semester control/control measures	Exam / Module Test, Calculation Work
Class schedule	http://rozklad.kpi.ua
Language of instruction	Ukrainian
Information about the course leader / lecturers	Lecturer: Prof. Y.I. Dzhezheria, dui_kpi@ukr.net, mobile +38(050)9681446 Practical classes: Assistant V.R. Lyakhovetskyi, Laboratory classes: Associate Professor T.I. Bratus
Course location	https://campus.kpi.ua (Sikorsky), distance learning platform

Course program

1. Description of the academic discipline, its purpose, subject matter, and learning outcomes

Description of **the discipline.** Physics is the science of nature, the most fundamental laws of motion of matter, its structure, properties, and interactions; it is based on establishing and explaining the laws governing the processes and phenomena of the surrounding world. Quality control of the knowledge gained is provided in the form of tests, calculations, and modular control works.

Subject of the discipline: General Physics.

Purpose of the academic discipline.

The purpose of the academic discipline is to develop the following competencies in students:

- the ability to think logically,
- generalization, analysis, perception of information, setting goals and choosing the right ways to achieve them,
- the ability to construct oral and written speech in a logically correct, reasoned, and clear manner,
- the ability to independently apply methods and means of cognition, learning, and self-control to acquire new knowledge and skills,
- the ability to formalize, present, and report on the results of work performed,
- the ability to present a scientific picture of the world that is adequate to the current level of knowledge based on knowledge of the basic principles and laws,
- apply the basic principles and laws of classical and modern physics,
- operate with fundamental physical concepts and laws when solving physical problems,
- apply basic material for further study of disciplines in the cycle of professional and practical training.

Main objectives of the academic discipline

In accordance with the requirements of the educational and professional program, after mastering the academic discipline, students should:

know:

- the basic methods of physical research;
- the fundamental laws of classical and modern physics;
- the limits of application of various physical concepts, laws, and theories.

be able to:

- apply physical laws to solve practical problems;
- assess the degree of reliability of results obtained using experimental or theoretical research methods;
- experimentally investigate, qualitatively and quantitatively evaluate basic physical phenomena;
- use general scientific and special terminology correctly.

possess:

- skills in the practical application of the laws of physics;
- experience in conducting physical experiments and processing their results;
- skills use standard methods and models to solving specific physical problems;
- skills in independent learning using traditional and modern educational and information technologies;
- methods of approaching problems that arise in the course of professional activity, choosing research methods based on a scientific worldview.

Program learning outcomes:
Competencies:

GC 1. Ability to think abstractly, analyze, and synthesize;

GC 2. Ability to apply knowledge in practical situations
GC 4. Ability to understand the subject area and professional activity
GC 7. Ability to learn and master modern knowledge.
PC 3. Ability to use basic methods, means, and tools for obtaining, transmitting, processing, and storing information.
PC 4. Ability to perform computer modeling of devices, systems, and processes using universal application software packages.
PC 15. Ability to perform calculations in the process of designing structures and means of information and telecommunication networks, telecommunication and radio engineering systems, in accordance with technical specifications using both standard and independently developed methods, techniques, and software tools for design automation.
PLO 1. Analyze, argue, and make decisions when solving specialized tasks and practical problems in telecommunications and radio engineering, which are characterized by complexity and incomplete certainty of conditions.
PLO 12. Apply fundamental and applied sciences to analyze and develop processes occurring in telecommunications and radio engineering systems.

2. Prerequisites and post-requisites of the discipline (place in the structural-logical scheme of training under the relevant educational program)

The study of this credit module is based on the disciplines of physics, mathematics, and chemistry in the scope of the secondary school program and the current material of the higher mathematics course.
Knowledge acquired by from the General Physics used in course Electrodynamics and Radio Wave Propagation.

3. Contents of the course

Section 1. Physical foundations of mechanics.

1.1 Fundamentals of kinematics.

1.2 The laws of conservation of momentum and angular momentum.

1.3 Dynamics of a material point and system.

1.4 Work and energy.

1.5 Gravitational interaction.

1.6 Dynamics of a rigid body.

1.7 Mechanical oscillations and waves. Section 2.

2.1 Potential electrostatic field.
2.2 Electrostatic field in the presence of dielectrics.
2.3 Electrical capacitance. Energy of an electric field.
2.4 Direct current.

Section 3. Quantum physics.
3.1 Elements of quantum mechanics.
3.2 Approximate model of the atom in quantum mechanics.
3.3 Elements of solid state physics.

Teaching materials and resources

Basic literature

1. Kucheruk I.M., Gorbachuk I.I., Lutsk P.P. General Course in Physics. Mechanics, Molecular Physics, and Thermodynamics. – Kyiv: Technika, 1999.
2. Kucheruk I.M., Gorbachev I.I. General Course in Physics. Electricity and Magnetism. - K: Technika, 2001.
3. Kucheruk I.M., Gorbachev I.I. General Course in Physics. Optics. Quantum Physics. - K: Technika, 1999.
4. Problems in General Physics. Sections "Mechanics," "Electricity and Magnetism." Compiled by V.P. Brygynets, O.O. Guseva, O.V. Dimarova, et al. – Kyiv: NTUU "KPI," 2011.
5. Problems in general physics. Section "Optics. Quantum physics. Molecular physics." Compiled by: V.P. Brygynets, O.O. Guseva, O.V. Dimarova, et al. – Kyiv: NTUU "KPI," 2011.

Supplementary literature

6. Saveliev I.V. Physics Course. – Moscow: Nauka, 1989, vols. 1, 2, 3.
7. Sivukhin D. V. General Course in Physics. – Moscow: Nauka, 1977–1986, vols. 1, 3, 4.
8. Irodov I. E. Mechanics. Fundamental Laws. – Moscow: Laboratory of Basic Knowledge, 2000.
9. Irodov I.E. Wave Processes. Moscow: Laboratory of Basic Knowledge, 1999.
10. Irodov I.E. Quantum Physics. Moscow: Laboratory of Basic Knowledge, 2001.

Information resources

1. http://kzf.kpi.ua/
2. http://campus.kpi.ua/tutor/index.php
3. www.youtube.com/irepalov

Educational content

4. Methodology for mastering the academic discipline (educational component) Lectures (full-time education)

Title, lecture topics, and list of key questions (list of teaching aids, references to literature)
Topic 1.1. Kinematics. Lecture 1-2. Kinematics of a point. Space and time. Mechanical motion. Reference frame. Kinematic description of motion. Trajectory, path and displacement, velocity and acceleration. General equations of kinematics of a material point. Models of classical mechanics: material point (particle), system of material points, absolutely rigid body. Tangential, normal, and total acceleration. Translational, rotational, and planar motions of a rigid body. Angular displacement, angular velocity, and angular acceleration. Relationship between angular and linear quantities.
Topic 1.2 Momentum, angular momentum. Lecture 3-4. Law of conservation of momentum. Center of mass. Momentum of a material point and system, relationship between momentum and force. Law of conservation of momentum. Center of mass of a system, law of motion of the center of mass. Concept of angular momentum of a material point. Conservation of angular momentum in a closed mechanical system and in a field with axial symmetry.

Topic 1.3. Fundamentals of dynamics. Lecture 5-6. Basic laws of classical mechanics. Inertial reference frames. Force and mass. The basic equation of motion of a classical particle. The main problem of dynamics. Newton's laws, their general meaning and limits of applicability. Features of motion in non-inertial reference frames. Forces of inertia. Forces of inertia in rotating reference frames.
Topic 1.4 Work and energy. Lecture 7-8. Conservative forces. Potential energy of a material point and a mechanical system. Kinetic energy of a mechanical system. Conservation of total mechanical energy in conservative systems. Non-conservative and dissipative forces, work of dissipative forces.
Topic 1.5 Gravitational interaction. Lecture 9-10. Gravitational force of gravitational interaction of point masses. Gravitational field. Principle superposition, tension, and potential of the gravitational field. Gauss's theorem for the gravitational field. Elements of celestial mechanics. Kepler's laws. First and second cosmic velocities.
Topic 1.6. Dynamics of a rigid body. Lectures 11–13. Equation of moments. Angular dynamic quantities. Angular momentum and torque. Moment equations for a particle and a system of particles. The law of conservation of angular momentum. Equations of rotational motion. Angular momentum and torque relative to the axis. Moment of inertia. Equations of rotational motion of a rigid body. Kinetic energy of a body during rotational and planar motion of a rigid body. Calculation of moments of inertia of rigid bodies, Steiner's theorem.
Topic 1.7. Mechanical oscillations. Lecture 14-15. Equation of natural harmonic oscillations and its solution. Small oscillations of elastic, mathematical, and physical pendulums. Energy of a harmonic oscillator. Equation of damped oscillations and its solution. Damping coefficient. Equation of forced oscillations and its solution. Resonance. Quality factor. Addition of several oscillations. Beating. Parametric resonance.
Topic 2.1. Potential electrostatic field. Lecture 16-17. Electric charge and its physical properties. Electric charge density. Point charges. Electric current and current density. Relationship between charge density and current density. Coulomb's law. Electrostatic field strength. Superposition principle for field strength. Field interpretation of Coulomb's law. Concepts of vector field flux and vector divergence. Ostrogradsky-Gauss formula. Field lines, its sources and sinks. Gauss's theorem in integral and differential forms. Potential energy of interaction of point charges. Potential of an electrostatic field and its properties. Condition of potentiality. Superposition principle for potentials. Laplace and Poisson equations for scalar potential. Boundary conditions for the field on the surface. Electrostatic protection.
Topic 2.2. Electrostatic field in the presence of dielectrics. Lectures 18-19. Dipole moment. Potential and field strength of a dipole. Electric dipole in an external field. Polarization of matter. Bound charges. Polar and nonpolar molecules. Electric field induction vector D and its boundary conditions.
Topic 2.3. Capacitance of a conductor. Lecture 20. Unit of measurement of capacitance. Capacitor. Charge, energy, and capacitance of a capacitor. Capacitance of a capacitor bank. Types of capacitors and their capacitance.

Topic 2.4. Direct electric current. Lectures 21-23. External forces and resistance. Ohm's law for a section of a circuit and for a complete circuit. Integral and differential forms of Ohm's law. Specific resistance and electrical conductivity. The law of conservation of energy for an electromagnetic field. Joule heat. The law of conservation of charge. Continuity equations.
Topic 3.1. Fundamentals of quantum mechanics. Lectures 24-26. Wave properties of matter particles. De Broglie hypothesis. Electron diffraction. Quantum description of the state of a microparticle. Wave function, its probability content and properties. Uncertainty principle, Heisenberg's relations. Heisenberg's relations. Estimated calculations using Heisenberg's relations. Explanation of the tunnel effect. Limits of the classical method of description. Time-dependent and stationary Schrödinger equations. Passage of a particle under a potential barrier (tunnel effect). Tunnel phenomena.
Topic 3.2. Approximate model of the atom in quantum mechanics. Lecture 27. Quantum states of the hydrogen atom. Determination of the energy states of the hydrogen atom based on Heisenberg's uncertainty principle.
Topic 3.3. Elements of solid state physics. Lectures 28-30. Crystals. Types of crystal lattices. Theory of free electrons in metals. Band theory of solids. Energy and Fermi level. Metals, semiconductors, dielectrics. Intrinsic and extrinsic conductivity of semiconductors. p-n and n-p-n junctions. Contact potential difference. Hall effect. Thermionic emission. Seebeck and Peltier effects.

Practical classes

No.	Lesson topic and list of key questions
1	Topic 1.1. Kinematics. Basic quantities and equations of kinematics of a point in translational and rotational motion.
2	Topic 1.2 Momentum. The law of conservation of momentum. Center of mass of a system. Momentum of a material point.
3	Topic 1.3. Fundamentals of dynamics. Force momentum. Newton's laws. Non-inertial reference frames. Inertial forces in rotating reference frames.
4	Topics 1.4 and 1.5. Potential and kinetic energy of a material point and a mechanical system. The law of conservation of total mechanical energy in conservative systems. Force of gravitational interaction of point masses. Principle of superposition, tension, and potential of a gravitational field.
5	Topic 1.6. Equations of rotational motion. Moment of inertia. Calculation of moments of rigid bodies, Steiner's theorem.
6	Topic 1.6. Equations of rotational motion of a rigid body. Kinetic energy of a body in rotational and planar motion of a rigid body.
7	Topic 1.7. Mechanical oscillations. Characteristics of harmonic oscillations. Dynamics of of harmonic oscillations.

8	Topic 2.1. Coulomb's law. Electrostatic field strength. Superposition principle for intensity. Field interpretation of Coulomb's law.
9	Topic 2.1. The concept of vector field flux. Gauss's theorem in integral and differential forms.
10	Topic 2.2. Electrostatic field in the presence of dielectrics. Dipole, dipole moment.
	Electric field induction vector D and its boundary conditions.
11	Topic 2.3. Electric capacitance, capacitors. Capacitor connections
12	Topic 2.4. Direct current. Ohm's law. Branched circuits, Kirchhoff's rules.
13	Topic 3.1. Corpuscular properties of radiation. Wave properties of particles. Schrödinger equation
14	Topic 3.2. Structure of the atom. Quantum states of the hydrogen atom
15	Topic 3.3. Elements of solid state physics. Metals, semiconductors, dielectrics. The Hall effect. Hall

Laboratory workshop

The main objectives of the laboratory course are to develop students' experimental skills, familiarize them with the main methods of accurate measurement of physical quantities, the main methods of processing experimental results, and physical instruments.

No No	Name of laboratory work	Number aud. hours
1	Study the laws of using using Maxwell's pendulum .	2
2	Determining the acceleration of free fall using a physical pendulum.	2
3	Study of the electrostatic field.	2
4	Determination of conductor resistance using a constant current bridge current bridge.	2
5	Determining the capacitance of a capacitor using the ballistic galvanometer method.	2
6	Measuring the magnetic field induction of an electromagnet.	2
7	Determination of the specific charge of an electron using the magnetron method.	2

Calculation work (full-time education):

In order to improve the quality of learning and develop initial experience in engineering calculations, individual assignments in the form of a calculation assignment (CA) on the topic: "Electric field of charges in a vacuum" are provided.

Policy and control

5. Policy of the academic discipline (educational component)

System of requirements for students:

- Attendance at lectures and practical classes is a mandatory part of studying the material.
- During lectures, the instructor uses their own presentation materials, Google Drive, and the Sikorsky distance learning platform to teach the current lecture material, provide additional information, assign practical tasks, etc. Solutions to practical tasks and modular tests are uploaded to Google Drive.
- Questions during lectures are asked during the time allotted for this purpose.
- To defend practical or computational work, it is necessary to solve the corresponding problems and answer questions about the solution.
- Modular tests assignments are written on practical classes without the use of auxiliary devices (mobile phones, tablets, etc.);
- completion of laboratory practical work;
- bonus points are awarded for: independent original solutions to problems in practical classes; participation in faculty and institute competitions in academic disciplines, participation in contests, certificates of completion of distance or online courses. The number of bonus points is limited to 10;
- Penalty points are awarded for: cheating on a module test or calculation work. The number of penalty points shall not exceed 10.

6. Types of control and rating system for assessing learning outcomes (RSO)

The rating of a full-time student consists of points that he or she receives for:

1. Modular test;
2. Homework (calculations);
3. Work in practical classes (homework);
4. Completion of laboratory practical work.
5. Exam answers;
6. Bonus and penalty points.

Rating point system and evaluation criteria Calculation work:
Weighted score RR = 10 with the following assessment criteria:

- 0 points - work not submitted within one month after the deadline (not counted);
- 1 - 2 points - the work contains gross errors in each task (not counted);
- 3 - 4 points - the work contains gross errors that require reworking (not counted);
- 5 - 7 points - the work contains some significant errors, but does not require complete reworking (accepted);
- 8–10 points—the work is generally correct, with no significant flaws or comments (pass).

Practical tasks (homework):
The total weighted score for practical classes during the semester is 7 points, which is calculated as the average of the number of grades, with the following assessment criteria for the class: 0 points - complete unpreparedness for the class (uncompleted homework) (lack of basic knowledge on the topic of the class);
1–2 points - unsatisfactory preparation for the class (unsatisfactory homework);

3–4 points - satisfactory preparation for the class (satisfactory homework); 5–6 points - good preparation for the class (well-done homework);
7 points - excellent preparation for class (excellent homework).

Modular tests/quizzes:
Ongoing assessment of knowledge is conducted throughout the semester in the form of 5 tests (control works). The weighted score for each test (control work) = 5.
Total weighted score for tests

$$R_{mkr} = 5 \times 5 = 25 \text{ points.}$$

Laboratory practical work:
For completing 6 laboratory assignments, points R_{lab} are awarded according to the following criteria:
0 points - the student is not admitted to the work;
1 point - the work is completed, but the calculations are not submitted on time;
2 points - the work has been completed, the calculations have been submitted on time and accepted by the teacher.
3 points - work completed, calculations submitted on time, theory defended.
$R_{lab} = 3 \times 6 = 18$ *points.*

Tests (control works):

0 points - no tasks completed;
1 point - at least 20% of tasks completed;
2 points - at least 40% of tasks completed;
3 points - at least 60% of tasks completed;
4 points - at least 85% of tasks completed.
5 points - 90-100% of tasks completed.

Bonus points
for creative work in the credit module (e.g., participation in faculty and institute academic competitions, participation in contests, certificates of completion of distance or online courses, active participation in practical classes), but no more than 10 in total.

The rating scale for the discipline R_D =100 points and is formed from the total weighted score for work during the semester (starting rating) R_C and the exam component R_E :
$R_D = R_C + R_E$
According to the above
$R_C = R_{pr} + R_{dkr} + R_{lab} + R_{mkr} = 60$ points+ $(R_z - R_{sh})$
where R_{pr} is the score for the practical assignment (0…7);
R_{mkr} – score for writing the MCR (0…25);
R_{calc} – score for writing the calculation work (0…10);
R_{lab} – points for laboratory practical work (0…18);
R_z – incentive points (0…10);
$R_{ш}$ – penalty points (0…10).
The exam component accounts for 40% of the rating scale and amounts to
$R_E = 40$ points.

Homework assignment (calculated work):
"excellent", complete answer to questions during the defense (at least 90% of the required information), tasks solved completely and correctly, solution justified – 9-10 points;
"good", sufficiently complete answer to the question during the defense (at least 75% of the required information), tasks solved completely and correctly – 7-8 points;
"satisfactory," incomplete answer to the question during the defense (at least 60% of the required information), minor errors in solving the problems – 5-6 points;
"unsatisfactory" – unsatisfactory answer and/or significant errors in solving the problems – 0-4 points.

Modular test:
"excellent", complete answer to the question during the defense (at least 90% of the required information), problems solved completely and correctly, solution justified – 20-25 points;
"good," sufficiently complete answer to questions during defense (at least 75% of the required information), problems solved completely and correctly – 17-19 points;
"Satisfactory," incomplete answer to the question during the defense (at least 60% of the required information), minor errors in solving the problems – 12-16 points;
"unsatisfactory", unsatisfactory answer and/or significant errors in solving the tasks – 0-11 points.

Knowledge assessment system in the exam:

- answers to all questions on the exam paper are missing or contain gross errors and do not meet the minimum required level of mastery of the material 0 - 9 points;
- the answers are generally correct for at least 25% of the exam questions 10 - 15 points
- correct answers to at least 50% of the exam questions 16 - 25 points
- correct answers to at least 75% of the test questions 26–35
- Comprehensive, well-reasoned answers to all questions on the exam 35–40

Conditions for admission to the exam: A
student is admitted to the exam if they:

- has a starting rating greater than or equal to $0.5\ R_C$,
- has completed the calculated work;
- has a pass mark for laboratory work.

The sum of RD points is converted to a credit grade according to the table:
Table. Conversion of rating points to grades on the university scale

Number of points	Grade
100-95	Excellent
94	Very good
84	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactory
Admission requirements not met	Not admitted

The working program of the academic discipline (Syllabus)
was compiled by: Professor of the Department of General Physics, FMF, Doctor of Physical and Mathematical Sciences Y.I. Dzhezherya; Associate Professor of the Department of General Physics, FMF, Candidate of Physical and Mathematical Sciences T.I. Bratus; Assistant Professor of the

Department of General Physics, FMF V.R. Lyakhovetsky.

Approved by the Department of General and Theoretical Physics, Protocol No. 5 dated May 27, 2025.

Approved by the Methodological Commission of the Radio Engineering Faculty (Protocol No. 06-2025 dated June 26, 2025).