GENERAL PHYSICS 1

Work program of the academic discipline (Syllabus)

Course details

Level of higher education First (bachelor's)

Field of knowledge	17 Electronics, Automation, and Electronic Communications
Specialization	172 Electronic communications and radio engineering
Educational program	For all educational programs
Status of discipline	Mandatory
Form of study	Full-time (day)
Year of study, semester	1st year, first semester
Scope of the discipline	120 hours (full-time: 36 hours – lectures, 36 hours – practical lessons, 48 hours – independent study)
Semester control/control measures	Exam / Module test, Calculation work
lesson schedule	http://rozklad.kpi.ua
Language of instruction	Ukrainian
Information about the course supervisor / lecturers	Lecturer: Prof. Y.I. Dzhezheria,dui_kpi@ukr.net , mobile +38(050)9681446 Practical Prof. Y.I. Dzhezheria,dui_kpi@ukr.net , mobile +38(050)9681446
Course location	https://campus.kpi.ua (Sikorsky), distance learning platform

Curriculum

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 course is to develop the following competencies in students:

- the ability to think logically,
- generalization, analysis, perception of information, setting goals, and correctly choosing ways to achieve them achieving them,
- be able to construct oral and written speech in a logically correct, reasoned, and clear manner,
- be able to independently apply methods and means of cognition, learning, and self-control to acquire new knowledge and skills,

- be able to formalize, present, and report the results of work performed,
- be able 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 lessonical 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.

The main tasks of the academic discipline

According to the requirements of the educational and professional program, after mastering the academic discipline, students should:

know:

- the basic methods of physical research;
- the basic laws of lessonical 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 using standard methods and models for solving specific physical problems;
- skills for independent acquisition of knowledge using traditional and modern educational and information technologies;
- methods of approaching the solution of 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 7. Ability to learn and master modern knowledge.

PLO 13. 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 physics, mathematics, and chemistry at the high school level and current material from the higher mathematics course.
The knowledge gained by students in the General Physics course is used in the courses Computer Science, Fundamentals of Circuit Theory, Electrodynamics, and Radio Wave Propagation.

3. Contents of the course

Section 1. Physical foundations of mechanics.

1.1 Fundamentals of kinematics.

1.2 Laws of conservation of momentum and angular momentum.

1.3 Dynamics of a material point and system.

1.4 Work and energy.

1.5 Dynamics of a rigid body.

1.6 Mechanical oscillations and waves.

Section 2. Optics.

2.1 Geometric optics.

2.2 Wave interference.

2.3 Wave diffraction.

2.4 Polarization of waves.

4. Corpuscular properties of light.

5. Teaching materials and resources

Basic literature

1. Kucheruk I.M., Gorbachev I.I., Lutsky 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. Optics. Quantum Physics. – Kyiv: Technika, 1999.
3. Problems in General Physics. Section "Mechanics." Compiled by V.P. Brygynets, O.O. Guseva, O.V. Dimarova, et al. – Kyiv: NTUU "KPI," 2011.
4. 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.

Information resources

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

Educational content

6. 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. References: [1], §§ 1.1, 1.3,1.4;[7], §§ 1.1. Models of lessonical mechanics: material point (particle), system of material points, absolutely rigid body. References: [1], §§ Introduction; [7], §§ Introduction. 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. References: [1], §§ 1.2, 1.5, 1.6; [7], §§ 1.2.
Topic 1.2 Momentum. Lecture 3-4. The 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. References: [1], §§ 2.3, 2.5; [7], §§ 3.1-3.5.
Topic 1.3. Fundamentals of dynamics. Lecture 5-6. Basic laws of lessonical mechanics. Inertial reference frames. Force and mass. Basic equation of motion of a lessonical particle. The main problem of dynamics. Newton's laws, their general meaning and limits of applicability. Laws of forces. Literature: [1], §§ 2.1-2.5,5.1,5.2; [7], §§ 2.2-2.4. Description of motion in non-inertial reference frames. Inertial forces. Inertial forces in rotating reference frames. Literature: [1], §§ 8.1-8.4; [7], §§ 2.5.
Topic 1.4. Work and energy. Lecture 7-8. Work and power of a force. Work of a variable force. Kinetic energy of a point and a mechanical system. References: [1], §§3.1-3.3; [7], §§4.1. Conservative forces. Potential energy of a point and a mechanical system. Non-conservative and dissipative forces, work of dissipative forces. Literature: [1], §§ 3.4; [7], §§ 4.2 -4.4. Total mechanical energy of a system. Relationship between total mechanical energy and work done by forces. Law of conservation of mechanical energy. References: [1], §§ 3.5-3.7; [7], §§ 4.5, 4.6. The relationship between potential energy and force. Conversion of mechanical energy into other forms, the general physical law of conservation of energy. References: [1], §§ 3.1 - 3.5; [7], §§4.1-4.6.
Topic 1.5. Dynamics of a rigid body. Lectures 9-10. Moment equations. Angular dynamic quantities. Angular momentum and torque. Equations of moments for a particle and a system of particles. Law of conservation of angular momentum. References: [1], §§ 2.9; [7], §§ 5.1-5.3. Equations of rotational motion dynamics. 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. References: [1], §§ 2.9,4.1-4.3;[4], §§ 5.1,5.4. Calculation of moments of inertia of rigid bodies, Steiner's theorem. Dynamics of planar motion of a body. References: [1], §§4.2; [7], §§ 5.4.
Topic 1.6. Mechanical oscillations. Lectures 11-12. 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. Elements of optics. Lecture 13. Light waves. Reflection and refraction of light. Electromagnetic nature of light. Light waves. Refractive index. Laws of reflection and refraction of light. Literature: [2], §§1.1, 2.2; [8], §§ 3.1,3.2
Topic 2.2. Wave interference. Lecture 14. Light interference. Concepts of interference and coherence. Difference in path length, general conditions for maxima and minima in two-beam interference. Literature: [3], §§ 3.1,3.3; [6], §§ 4.1,4.2. Obtaining coherent light beams, interference patterns. Interference in thin plates. Interference of counter waves, standing light waves. References: [2], §§ 3.2, 3.4; [8], §§ 4.3,4.4.
Topic 2.3. Wave diffraction. Lecture 15. Light diffraction. Wave diffraction, Huygens-Fresnel principle. Fraunhofer diffraction on a single slit and on a one-dimensional grating. Diffraction of X-rays on crystals, Wolff-Bragg formula. Literature: [2], §§ 4.1,4.3,4.4; [8], §§ 5.1,5.4-5.7.
Topic 2.4. Wave polarization. Lecture 16. Light polarization, light dispersion Independent work: Polarized and natural light, types of polarization. Malus' law. Light polarization upon reflection from a dielectric and upon double refraction. Literature: [2], §§ 5.1,5.2,5.4,5.6;[8], §§ 6.1-6.3. Concept of wave dispersion. Elementary electronic theory of light dispersion, normal and anomalous dispersion. Concept of wave packet and group velocity. Literature: [2], §§ 6.1-6.3; [8], §§ 7.1-7.3.
Topic 2.5. Corpuscular properties of light. Lectures 17-18. Thermal radiation, photons. Characteristics of thermal radiation. Laws of radiation of a black body. Quantum hypothesis, Planck's formula. Photons, energy, mass, and momentum of a photon. Literature: [2], §§ 9.4;], §§ 11.1-11.4.; [9], §§ 1.1,1.4. Photoelectric effect. Patterns and elementary quantum theory of the external photoelectric effect, Einstein's equation. Braking X-ray radiation. Short-wave limit of the braking spectrum. Literature: [2], §§ 9.1-9.3, 10.1; [9], §§ 1.2,1.3 . The Compton effect and its elementary theory. Interaction of photons with matter. References: [2], §§ 10.2; [9], §§ 1.5.

Practical lessons (full-time education)

No	Name of the topic and list of main questions
1	Topic 1.1. Kinematics. Basic quantities and equations of point kinematics.
2	Topic 1.1. Tangential, normal, and total acceleration. Translational and rotational motion of a material point.
3	Topic 1.2 Momentum. The law of conservation of momentum. Momentum of a material point.
4	Topic 1.3. Fundamentals of dynamics. Force impulse. Newton's laws. Center of mass.
5	Topic 1.3. Fundamentals of dynamics. Motion of a body under the action of variable forces.
6	Topic 1.4. Work and energy. Kinetic and potential energy of a body. Work done by a force.
7	Topic 1.4. Work and energy. Total mechanical energy of a system. Law of conservation mechanical energy.
8	Topic 1.4. Work and energy. The relationship between total mechanical energy and the work of forces.
9	Topic 1.5. Dynamics of a rigid body. Momentum and moment of inertia of a body. Condition of equilibrium of a body.
10	Topic 1.5. Dynamics of a rigid body. Equation of dynamics of rotational motion of a rigid body.
11	Topic 1.5. Dynamics of a rigid body. Energy of a rigid body. Work of a torque.

12	Topic 1.5. Dynamics of a rigid body. Laws of conservation of energy and angular momentum of a body.
13	Topic 1.6. Mechanical oscillations. Free harmonic oscillations.
14	Topic 1.6. Mechanical oscillations. Damped and forced oscillations.
15	Topic 2.1. Geometric optics. Topic 2.2. Wave interference.
16	Topic 2.3. Wave diffraction.
17	Topic 2.4. Wave polarization. Malus' and Brewster's laws.
18	Topic 2.5. Corpuscular properties of light. Photoelectric effect. Compton effect. Final lesson.

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 calculation work (CW) on the topic: "Mechanics of a material point" are provided.

Policy and control

7. Policy of the academic discipline (educational component)

System of requirements for students:

- attendance at lectures and practical lessons is a mandatory part of studying the material;
- the lecturer uses their own presentation materials during lectures; uses Google Drive and the Sikorsky distance learning platform to teach the current material
  lecture, additional information, practical work assignments, etc.; solutions to practical problems and Module test s 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;
- Module test s are written during practical lessons without the use of auxiliary means (mobile phones, tablets, etc.).
- Bonus points are awarded for: independent original solutions to practical tasks; participation in faculty and institute academic competitions in academic disciplines;
  participation in competitions, certificates of completion of distance or online courses. The number of incentive 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.

8. 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. Module test s;
2. homework assignments;
3. work in practical lessons;
4. exam answers;
5. bonus and penalty points.

Rating point system and assessment criteria Full-time education:

Homework assignment:

Weighted score of homework = 20 with the following assessment criteria:

- 0 points - work not submitted within one month after the deadline (not counted);
- 1 - 4 points - the work contains gross errors in each task (not counted);

- 5 - 8 points - the work contains gross errors that require reworking (not counted);
- 9–14 points – the work contains some significant errors, but does not require complete rewriting (pass);
- 15 - 20 points - the work is generally correct, has no significant flaws or comments (pass).

Practical tasks:

The total weighted score for practical lessons during the semester is 20 points with the following assessment criteria: 0 points - complete unpreparedness for the lesson (lack of basic knowledge on the topic of the lesson);
1–2 points - unsatisfactory preparation for the lesson;
3 points - satisfactory preparation for the lesson;
4 points - good preparation for the lesson;
5 points - excellent preparation for the lesson.

Module test:
0 points - no tasks completed; 2 points - less than 20% of tasks completed;
5 points - at least 30% of tasks completed; 8 points - at least 50% of tasks completed; 10 points - at least 70% of tasks completed; 15 points - at least 85% of tasks completed. 20 points - 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 lessons), but no more than 10 points 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 examination component R_E:

$$R_D = R_C + R_E$$

According to the above

$$R_C = R_{pr} + R_{dkr} + M_{kr} = 60 \text{ points} + (R_z - R_{sh})$$

where R_{pr} is the score for the practical task (0...20);
$R_{мкр}$ – points for writing the Module test (0…20);
$R_{дкр}$ – points for writing the calculation work (0…20);
$R_з$ – incentive points (0…10);
$R_ш$ – penalty points (0…10).
The exam component accounts for 40% of the rating scale and is equal to

$$R_E = 40 \text{ points.}$$

Correspondence course:

Practical assignments:

"Excellent," complete answer to the question (at least 90% of the required information), practical task solved correctly – 9-10 points;
"good", sufficiently complete answer to the question (at least 75% of the required information), practical task solved correctly – 8 points;
"satisfactory", incomplete answer to the question during the defense (at least 60% of the required information), minor errors in solving the practical task – 6-7 points;
"unsatisfactory," unsatisfactory answer and/or significant errors in solving the practical task – 0-6 points.

Homework assignment:

"Excellent": complete answer to the question during the defense (at least 90% of the required information), tasks solved completely and correctly, solution justified – 18-20 points;
"Good," sufficiently complete answer to the question during the defense (at least 75% of the required information), tasks solved completely and correctly – 15-17 points;
"Satisfactory," incomplete answer to the question during the defense (at least 60% of the required information), minor errors in solving the problems – 10-14 points;
"unsatisfactory", unsatisfactory answer and/or significant errors in solving the tasks – 0-9 points.

Module test :
"Excellent": complete answer to the question during the defense (at least 90% of the required information), tasks solved completely and correctly, solution justified – 18-20 points;
"Good," sufficiently complete answer to the question during the defense (at least 75% of the required information), tasks solved completely and correctly – 15-17 points;
"Satisfactory," incomplete answer to the question during the defense (at least 60% of the required information), minor errors in solving the problems – 10-14 points;
"unsatisfactory", unsatisfactory answer and/or significant errors in solving the tasks – 0-9 points.

The rating scale for the discipline (correspondence form of study) $R_D = 100$ points and is formed from the total weighted score for work during the semester (starting rating) R_C and the examination component R_E:

$$R_D = R_C + R_E$$

According to the above

$$R_C = R_{pr} + R_{mkr} + R_{DR} = 50 \text{ points where } R_{pr}$$

is the score for the practical assignment (0...10);
$R_{мкр}$ – score for writing Module test (0…20);
$R_{ДКР}$ – score for writing a calculation assignment (0…20);

The exam component accounts for 50% of the rating scale and amounts to

$$R_E = 50 \text{ points.}$$

Exam assessment system:

- 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 - 19 points
- correct answers to at least 50% of the exam questions 20 - 29
- correct answers to at least 75% of the test questions 30–39
- Comprehensive, well-reasoned answers to all questions on the exam 40–50

Conditions for admission to the exam:
A student is admitted to the exam if he/she:
- has a starting rating greater than or equal to $0.5\ R_C$,
- has completed the assigned calculation work;

The sum of RD points is converted to a credit grade according to the 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

Work program for the academic discipline (Syllabus):

Compiled by Professor of the Department of General Physics, FMF, Doctor of Physical and Mathematical Sciences Y.I. Dzhezherey.

Approved by the Department of General and Theoretical Physics, Protocol No. 8 dated June 18, 2024.

Approved by the Methodological Commission of the Radio Engineering Faculty (Protocol No. 06/2024 dated 28 June 2024).