GENERAL PHYSICS 2

Curriculum of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	17 Electronics, Automation, and Electronic Communications
Special	172 Electronic communications and radio engineering
Educational program	For all educational programs
Status of discipline	Mandatory
Form of study	Full-time (day)/part-time
Year of study, semester	1st year, second semester
Scope of the discipline	240 hours (daytime: 72 hours – lectures, 36 hours – practical lessons, 18 hours – laboratory work, 114 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, distance learning platform "Sikorsky"

Curriculum

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

Description of the discipline. Physics is the science of nature, of the most fundamental laws governing the 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 acquired 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 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.

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 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 use standard methods and models to solving specific physical problems;
- skills for independent acquisition of knowledge 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:

2. GC 1. Ability to think abstractly, analyze, and synthesize;
3. GC 2. Ability to apply knowledge in practical situations
4. GC 7. Ability to learn and master modern knowledge.
5. PLO 13. Apply fundamental and applied sciences to analyze and develop processes occurring in telecommunications and radio engineering systems.

6. 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.

The knowledge gained by students from the General Physics course is used in the courses Computer Science, Fundamentals of Circuit Theory, Electrodynamics, and Radio Wave Propagation.

7. Contents of the course

Section 3. Electricity and magnetism.

3.1 Potential electrostatic field.
3.2 Electrostatic field in the presence of dielectrics.
3.3 Electric capacitance. Electric field energy.
3.4 Direct current.
3.5 Stationary magnetic field.
3.6 Law of electromagnetic induction.
3.7 Alternating electric current.
3.8. Electromagnetic oscillations.
3.9. Maxwell's equations
3.10 Motion of charged particles in an electromagnetic field. Section 4. Quantum physics.
4.1 Quantum mechanics.
4.2 Approximate model of the atom in quantum mechanics.
4.3 Solid state physics.

8. Teaching materials and resources

Basic literature

1. Kucheruk I.M., Gorbachuk I.I., Lutsk P.P. General Course in Physics. Optics. Quantum Physics. Kyiv: Tekhnika, 1999.
2. Kucheruk I.M., Gorbachev I.I. General Physics Course. Electricity and Magnetism. - K: Technika, 2001.
3. General Physics. Electricity and Magnetism. Collection of Problems for Students of Technical Specialties. V.P. Brygynets, O.O. Guseva, O.V. Dimarova, et al. – Kyiv. NTUU KPI. 2011. – 52 p.
4. General Physics. Optics. Quantum Physics. Molecular Physics. Collection of Problems for Students of Technical Specialties. V.P. Brygynets, O.O. Guseva, O.V. Dimarova, et al. – Kyiv. NTUU KPI. 2010. – 50 p.
5. V.P. Brygynets, O.O. Guseva. Calculation work: "Electric field of charges in a vacuum."

Information resources

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

Educational content

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

Title, lecture topics, and list of main questions
Topic 3.1. Potential electrostatic field. Lecture 1-2. 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, sources, and sinks. Gauss's theorem in integral and differential forms. Potential energy of interaction between 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 shielding.
Topic 3.2. Electrostatic field in the presence of dielectrics. Lecture 3-4. 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 3.3. Capacitance of a conductor. Lecture 5. 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 3.4. Direct electric current. Lectures 6-8. External forces and emf. 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 electromagnetic fields. Joule heat. The law of conservation of charge. Continuity equation. Conductance current and displacement current. Physical nature of displacement current.

Topic 3.5. Stationary magnetic field.

Lectures 9-11. Biot-Savart law. Magnetic field of a moving charge. Field of volume and line currents. Interaction of parallel conductors with current. Ampere force. Unit of measurement of current in SI.

The law of total current. The concept of circulation vectors. Vector rotor. Stokes' formula. The law of total current in integral and differential forms. Solenoid field.

Magnetostatic equations. Boundary conditions for magnetic field and current. Field of a current-carrying loop.

Magnetic dipole. Field of a current-carrying loop. Magnetic dipole moment. Current-carrying loop in an external field.

Magnetic field in matter. Magnets. Magnetization of matter. Dia-, para-, and ferromagnetism. Magnetic susceptibility and permeability of matter. Magnetic field intensity vector and its boundary conditions.

Topic 3.6. Law of electromagnetic induction.

Lectures 12-14. Electromotive force. Integral and differential forms of the law of electromagnetic induction. Lenz's law.

The phenomenon of self-induction. Inductance of a conductor. Self-induction EMF. Energy of a conductor with current. Current when closing and opening an RL circuit.

The phenomenon of mutual induction. Mutual induction coefficient. Mutual induction emf. Current when closing and opening the CL circuit.

Topic 3.7. Alternating electric current.

Lectures 15-17. Quasi-stationary current. Ohm's law for alternating current. Impedance. Vector diagram for voltage across R, L, and C. Kirchhoff's laws for alternating current. Active and reactive resistance. Power in an alternating current circuit. Effective values of current and voltage.

Energy transfer through a wire. Energy transfer through a cable.

Topic 3.8. Free electromagnetic oscillations.

Lectures 18-20. Harmonic oscillations in a circuit.

Types of oscillations. Free and forced oscillations. Harmonic oscillations. Oscillatory circuit. Oscillations in an ideal circuit, natural frequency of the circuit. Energy of oscillations in an ideal circuit.

Free oscillations in a circuit with damping. Free damped oscillations in a circuit, frequency of damped oscillations. Damping characteristics. Energy dissipation in a circuit.

Forced electrical oscillations.

Forced oscillations in a circuit under sinusoidal influence. Amplitude and phase of forced oscillations. Resonance curves.

Topic 3.9. Maxwell's equations.

Lectures 21-24. Vortex electric field and displacement current.

Maxwell's equations. Fundamental and material equations. Plane electromagnetic waves. Monochromatic wave. Wave equation. Phase velocity of a wave. Properties of plane waves. Propagation of electromagnetic waves in dielectrics. Poynting vector, intensity of electromagnetic waves.

Propagation of electromagnetic waves in conductors. Maxwell's equations for waves in conductors and their solution in the form of plane waves. Dispersion equation. Skin effect.

Topic 3.10. Motion of charged particles in an electromagnetic field.

Lectures 25-26. Motion of charge in a uniform electric field. Motion in a uniform magnetic field. Cyclotron frequency. Motion in crossed fields. Particle drift. Charged particle accelerators. Principles of operation.

Topic 4.1. Fundamentals of quantum mechanics. Lectures 27-30. Wave properties of matter particles. De Broglie hypothesis. Electron diffraction. Quantum description of the state of a microparticle. Wave function, its probabilistic meaning and properties. The uncertainty principle, Heisenberg's relations. Heisenberg's relations. Estimated calculations using Heisenberg's relations. Explanation of the tunnel effect. Limits of the lessonical method of description. Time and stationary Schrödinger equations. Stationary states. Particle in a potential well. Harmonic oscillator. Passage of a particle under a potential barrier (tunnel effect). Tunnel phenomena.
Topic 4.2. Approximate model of the atom in quantum mechanics. Lectures 31-32. Quantum states of the hydrogen atom. Particles in a spherically symmetric field, bound and unbound states. Schrödinger's equation for the hydrogen atom and hydrogen-like ions. Stationary states and quantum numbers. Energy levels and optical spectrum of the hydrogen atom. Quantization of angular momentum and its projection. Degeneration of energy levels and electronic transitions in the hydrogen atom.
Topic 4.3. Solid state physics. Lectures 33-36. 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 transitions. Contact potential difference. Hall effect. Thermionic emission. Seebeck and Peltier effects.

Laboratory lessons (full-time education)

1. Study of the distribution of potential and intensity of an electrostatic field.
2. Study of the ballistic galvanometer.
3. Study of thermo-emf.
4. Determination of the specific charge of an electron using the magnetron method.
5. Study of the magnetic field of an electromagnet.
6. Investigation of damped oscillations in an oscillatory circuit.
7. Study of forced oscillations in an oscillatory circuit. Practical lessons (full-time education)

No	Name of the topic and list of main questions
1	Calculation of electric fields using the principle of superposition.
2	Electric field potential.
3	Calculation of electric fields using Gauss's theorem.
4	Electric field in dielectrics and conductors.
5	Capacitors. Energy of an electric field.
6	Direct current circuits. Joule's law.
7	Branched circuits, Kirchhoff's rules.
8	Calculation of magnetic fields according to the Biot-Savart law.
9	Calculation of magnetic fields using the circulation theorem.
10	Electromagnetic induction.
11	Self-induction. Magnetic field energy.
12	Quasi-stationary currents.
13	Transient processes.
14	Electrical oscillations.
15	Free and forced electrical oscillations.
16	Maxwell's equations.
17	Electromagnetic waves.
18	Movement of charge in electric and magnetic fields.

Calculation work (full-time education):

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

Policy and control

10. Academic discipline (educational component) policy

System of requirements for students:

- attendance at lectures and practical lessons is a mandatory part of studying the material;
- during lectures, the teacher uses their own presentation materials; uses Google Drive and the Sikorsky distance learning platform to teach the material of the current lecture, provide additional information, assign practical tasks, etc.;
- questions during lectures are asked during the time allotted for this purpose;
- to defend a practical or computational assignment, 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 problems in practical lessons; 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.

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

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

1. Module test s/online tests;
2. calculations;
3. completion of laboratory work;
4. work in practical lessons;
5. exam answers;
6. bonus points.

The rating of a part-time student consists of points awarded for:

1. completion and defense of homework assignments;
2. completion and defense of a Module test ;
3. completing laboratory work;
4. solving problems in practical lessons;
5. answers on exams;
6. bonus points

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Rating point system and assessment criteria

Full-time education: Calculation work:

Weighting score RR = 10 with the following assessment criteria:

- 0 points - work not submitted within a 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:

The total weight score for practical lessons during the semester is 10 points, which is calculated as the average of the number of grades, with the following assessment criteria for the lesson:

0 points - complete unpreparedness for the lesson (lack of basic knowledge on the topic of the lesson);
2–3 points - unsatisfactory preparation for the lesson; 4–
6 points - satisfactory preparation for the lesson;

7–8 points - good preparation for the lesson;
9-10 points - excellent preparation for the lesson.

Module test s/quizzes:

Ongoing assessment of knowledge is conducted throughout the semester in the form of 5 online tests. The weighted score for each test = 5.

Total weighting for tests

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

Laboratory workshop:

For completing 6 laboratory assignments, r_{lab} points are awarded according to the following criteria:

0 points - the student is not admitted to the work;
1 points - the work has been completed, but the calculations have not been submitted on time;
2 points - the work has been completed, the calculations have been submitted on time and accepted by the teacher.

For each laboratory assignment, points are awarded according to the following criteria:

0 points - the quality of answers is unsatisfactory;
1 points - satisfactory quality of answers;
2 points - the quality of answers is good;
3 points - the quality of answers is excellent.

The total weighted score for laboratory lessons during the semester is

$$R_{lab} = (2 \cdot r_{lab} + 3 \cdot r_{col})/2 = (2 \times 6 + 3 \times 6)/2 = 15 \text{ points.}$$

Incentive points R_{inc}:

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

The rating scale for the discipline (full-time education) 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

$$R_C = R_{lab} + R_{pr} + R_{pp} + R_{mkr} = 60 \text{ points} + R_z$$

where R_{lab} - points for laboratory practical work (0...15);
R_{pr} – points for practical assignments (0...10);
$R_{мкр}$ – points for writing Module test (0...25);
R_{pp} – points for writing the calculation paper (0…10);
$R_з$ – incentive points (0…10);
The exam component accounts for 40% of the rating scale and amounts to

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

Conditions for admission to the exam:
A student is admitted to the exam if he/she:
- has a starting rating of $R_C > 0.5\ R_C$, i.e. $R_C > 30$ points;
- have completed the calculated work.

Exam grading 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;
- data generally correct answers to at least 25% of the test questions 10–19 points
- correct answers in total for at least 50% of the tasks on the test sheet 20–29 points
- correct answers to at least 75% of the questions on the test 30– 39

points comprehensive, well-reasoned answers to all questions on the exam 40 – 50 points

Conditions for admission to the exam:

A student is admitted to the exam if they:
- have a starting rating greater than or equal to $0.5\ R_C$;
- has completed the assigned work.

The sum of RS points or points for the final assignment is converted to a final 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

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 of 18.06.2024.

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