МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
Ministry of Education and Science of Ukraine

Національний аерокосмічний університет ім. М.Є. Жуковського
“Харківський авіаційний інститут”
National Aerospace University
“Kharkiv Aviation Institute”

Кафедра Фізики
Physics Department

ДОПОВНЕННЯ
до силлабуса навчальної дисципліни
«ФІЗИКА»

ANNEX
to syllabus of educational component
PHYSICS

Переклад з української на англійську
Translation from Ukrainian to English

Використовується в освітньому процесі
з англійською мовою викладання
при підготовці фахівців
на першому (бакалаврському) рівні за
Спеціальностями: 113, 122, 134, 173, 272

It is used for training in English
on the bachelor degree level for
Specialties: 113, 122, 134, 173, 272

Харків
Kharkiv

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2. Description of the course

Distribution of class hours through terms and types of training

Terms	ECTS credits /hours	In class hours	Lectures	Recitations	Laboratory experiments	Self-training	Assessment methods
Term 1	**5/150**	**80**	32	32	16	**70**	Exam
Term 2	**5/150**	**80**	32	32	16	**70**	Exam
Total	**10/300**	**160**	64	64	32	**140**	

COURSE WORKLOAD

Overall: 10 ECTS credits/ 300 h, on 2 terms 16 weeks each/

Weekly: about 9 hours per week, 5 hours in class and 4 hours for self-training.

LEARNING OBJECTIVES

The purpose of the Physics course is to form an idea of the modern physical picture of the world, grant knowledge about the most important principles and laws that determine the structure and the simplest forms of motion of matter, and prepare students for a qualitative study of general technical and special educational components. By studying the physical phenomena, students learn to analyze data, construct logical chains, and make reasonable conclusions.

According to the requirements of the study program, students must achieve the following:

COMMON COMPETENCIES

1. Ability for abstract thinking, analysis and synthesis;
2. Ability to apply knowledge in practical situations;
3. Ability to generate new ideas (creativity).

SPECIFIC COMPETENCY

The ability to apply the conceptual and categorical apparatus, general methodology and methods of organizing engineering activities; analyze the needs and capabilities of production automation.

PROGRAM LEARNING OUTCOME

Use of methods of physical abstraction and modeling in describing complex systems.

ADDITIONAL LEARNING OUTCOMES

By the end of the Physics course, students

should know: fundamental notions, laws and theories of classical and modern physics; basic physical phenomena and their explanation; main methods of physical research; methods for computing physical problems;

should be able: to apply theoretical knowledge to physical analysis of observed phenomena and processes; to conduct a physical analysis of the problem; to solve typical problems; to estimate the accuracy of measurements; to use general-purpose measuring instruments; to process experimental data; to use reference literature.

INTERDISCIPLINARY RELATIONS

Physics course is the basis of special educational components that students study.

3. Structure of the educational component “Physics”

Topic\Type	Lectures	Recitations	Laboratory experiments	Self-training	Comment
1	**2**	**3**	**4**	**5**	**6**
1st Term (1.02)					
UNIT 1: Physical Principles of Mechanics					
1. Mechanical motion. Kinematics of a particle.	3	2	-	4	In the laboratory: 1 intro session 2 experiments and 1 defense session (2 hours each)
2. Dynamics of a particle and a system of particles.	3	2	2	4	
3. Kinematics and dynamics of rotational motion of a solid body.	3	2	2	4	
4. Mechanical work, power, energy. Potential force fields.	3	2	1	4	
5. Oscillating process. Simple harmonic motion.	2	2	2	8	
6. Damped and forced oscillations	1	1	-	5	
7. Wave process.	1	1	1	5	
Midterm Quiz	**-**	**-**	**-**	**2**	On after-classes hours
Total	**16**	**12**	**8**	**36**	
UNIT 2: Molecular Physics and Thermodynamics					
8. Statistical theory of ideal gas.	1	1	1	2	In the laboratory: 1 experiment (2 hours)
9. First and second laws of thermodynamics. Heat engines.	1	1	1	3	
10. Physical kinetics. Diffusion, viscosity, heat conductivity.	–	–	–	5	
Total	**2**	2	2	10	
UNIT 3: Electricity					
11. Electrostatic field in vacuum.	3	2	1	6	In the laboratory: 2 experiments and 1 defense session (2 hours each)
12. Gauss’s law	3	2	1	6	
13. Electrostatic potential. Conductors in electrostatic field.	3	2	1	6	
14. Electrostatic field in a medium. Electric capacitance.	3	2	1	6	
15. Direct current. DC circuits.	2	2	1	6	
Midterm Quiz	**-**	**-**	**-**	**2**	On after-classes hours
Total	**14**	**10**	**6**	32	
Total for the 1st term	**32**	**32**	**16**	**70**	

1	2	3	4	5	6
2nd Term (2.03)					
UNIT 4: Magnetism					
16. Effects of magnetic fields.	3	2	2	4	In the laboratory: 3 experiments and 2 defense sessions (2 hours each)
17. Sources of magnetic fields.	3	3	3	4	
18. Faraday's Law.	3	2	3	4	
19. Magnetic field in a medium. Inductance.	3	3	2	4	
20. Electrical oscillations and AC circuits.	–	–	–	8	
21. Maxwell's Equations. Electromagnetic Waves.	4	2	–	4	
Midterm Quiz	**-**	**-**	**-**	**2**	On after-classes hours
Total	**16**	**12**	**10**	**30**	
UNIT 5: Wave Optics and Modern Physics					
22. Interference of light.	3	2	1	4	In the laboratory: 2 experiments and 1 defense session (2 hours each)
23. Diffraction of light.	3	2	1	4	
24. Absorption, Polarization, and Dispersion.	3	2	1	4	
25. Holography.	–	–	–	8	
26. Elements of relativistic mechanics.	–	–	–	10	
27. Heat radiation.	3	2	1	4	
28. Quantum optics.	2	2	1	4	
29. Principles of quantum mechanics.	2	2	1	5	
30. Introduction to nuclear physics.	2	2	–	4	
Midterm Quiz	**-**	**-**	**-**	**1**	On after-classes hours
Total	**16**	**12**	**6**	**48**	
Total for the 2nd term	**32**	**32**	**16**	**70**	
Total over the course	**64**	**64**	**32**	**140**	

4. Course content of educational component "Physics"

UNIT 1: Physical Principles of Mechanics

LECTURES

Topic 1. Mechanical motion. Kinematics of a particle.

Mechanical motion is the simplest form of motion of matter. Properties of space and time in classical mechanics. Physical models: point particle, system of particles, rigid body, and solid state. Kinematics of a particle. Position vector, velocity and acceleration as derivatives of the position vector with respect to time. Normal and tangential acceleration. Radius of a curvature of the trajectory. Principal kinematics problem and methods of its solution.

Topic 2. Dynamics of translational motion of a particle and a rigid body.

Isolated system of bodies. Internal and external forces. Second Newton law in two forms. Principal problem of dynamics and the scheme of its solution. Centre of mass (centre of inertia) of mechanical system and law of its motion. Law of conservation of momentum as a fundamental law of nature. Motion of a body with varying mass. Rocket propulsion. Meshersky's equation. Tsiolkovsky rocket equation.

Topic 3. Kinematics and dynamics of rotational motion of rigid body.

Translational and rotational motion of a rigid body. Elements of kinematics of rotational motion. Vectors of angle of rotation, angular velocity and angular acceleration. Their relation with linear velocity and acceleration of rotating particles.

Torque about the point of rotation. Torque about the axis of rotation. Angular momentum of a particle and rigid body about point and axis of rotation. Moment of inertia of a particle, system of particles and rigid body about point and axis of rotation. Dynamics equation of rotational motion for rigid body. Moments of inertia of bodies with simple forms (disk, rod, cylinder, sphere). Parallel-axis theorem. Gyroscopic effect. Non–inertial frames of reference. Inertia forces.

Topic 4. Mechanical work, power, energy. Potential force fields.

Energy as a measure of various forms of motion and interaction. Work done by a variable force. Power. Work done by elastic, gravity, central forces. Kinetic energy of the mechanical system and its connection with work done by external and internal forces. Conservative and nonconservative forces. Gyroscopic forces. Work done in rotational motion. Kinetic energy of rotating and rolling body.

Field as a form of matter which is the cause of force interaction between particles of substance. Potential force fields. Condition for potentiality of force field. Potential energy of a particle in an external force field and its connection with a force exerted on a particle due to this field. Potential energy of gravitational field. Potential energy of elastically deformed body.

Potential energy of a system. Law of conservation of mechanical energy. Dissipation of energy. Law of conservation and transformation of energy. Application of conservation laws to elastic and inelastic collisions.

Topic 5 Oscillation process. Simple harmonic motion.

Oscillation process. Simple harmonic motion. Kinematics characteristics of Simple harmonic motion. Superposition of oscillations of the same direction. Beats. Phasor method. Superposition of the mutually perpendicular oscillations. Lissagy figures.

Differential equation of harmonic oscillations and its solution. Simple, physical and spring pendulum, periods of their oscillations. Energy of harmonic oscillation.

Topic 6. Damped and forced oscillations.

Differential equation of damped oscillations and its solution. Damping coefficient. Overdamped processes. Differential equation of forced oscillations and its solution. Amplitude, displacement and phase of the forced oscillation. Conception of resonance.

Topic 7. Wave processes.

Wave motion. Formation of mechanical waves in elastic medium. Longitudinal and transverse waves. Equation of traveling wave. Plane and spherical wave. Wavelength and wavenumber.

Differential wave equation. Phase speed and wave dispersion. Energy of waves. Principle of superposition of waves and boundaries of its application. Group speed. Group packet. Coherence of waves. Interference of waves. Standing waves. Equation of standing waves and its analysis.

RECITATIONS

1. Kinematics of translational motion.
2. Dynamics of translational motion.
3. Kinematics and dynamics of rotational motion.
4. Work and energy conservation law.
5. Mechanical oscillations and waves

LABORATORY EXPERIMENTS: UNIT 1

1. Moment of inertia of a flywheel.
2. Trifilar pendulum.
3. Viscosity coefficient measurements.
4. Speed of sound in air.

Each student has to conduct two experiments from the list according to instructor assignment.

UNIT 2: Molecular Physics and Thermodynamics

LECTURES

Topic 8. Statistical theory of ideal gas.

Thermodynamics systems. Statistic and thermodynamics methods of investigation. Thermal motion. Probability and fluctuations in thermodynamic system. Maxwell's

distribution over molecular speeds. Most probable, root mean square, mean arithmetic speeds. Stern experiment.

Exponential atmosphere. Boltzman' distribution as distribution of molecules in potential field. Gibb's distribution.

Thermodynamics parameters. Equilibrium state, equilibrium process and their representation at the thermodynamics diagrams. Main equation of kinetic theory. Clapeyron's equation of state. Average kinetic energy of molecules. Kinetic interpretation of temperature.

Ideal gas. Pressure of gas in statistical theory, Main equation of kinetic theory of gas. Mean kinetic energy of translational motion of molecules. Molecular interpretation of temperature. Degrees of freedom. Law of equipartition of energy over degrees of freedom. Internal energy of ideal gas.

Topic 9. First and second laws of thermodynamics. Heat engine

Work done by gas during its volume changes. Quantity of heat. First law of thermodynamics. Application of the first law of thermodynamics to isoprocesses and adiabatic process. Heat capacitance. Specific and molar heat capacitance. Dependence of heat capacitances on the type of process. Mayer formula. Classical kinetic theory of heat capacitance and its boundaries.

Reversible and irreversible processes. Cyclic process. Heat engine and refrigerate machines, theirs efficiency. Carno cycle and its efficiency. Second law of thermodynamics. Clausius inequality. Entropy. Entropy of ideal gas. Statistical interpretation of second law of thermodynamic. Thermodynamic probability of state of the gas. Boundaries of ideal gas model. Real gas. Force and potential energy of intermolecular interaction. Van der Waals equation. Comparison of Van der Waals isotherms with experimental ones. Phase transformation of I and II type. Critical state. Internal energy of real gas. Properties of liquid and solid states.

Topic 10. Physical kinetics. Diffusion, viscosity, heat conductivity.

Average number of collisions. Transport phenomena in thermodynamically nonequilibrium systems. Experimental laws of diffusion, thermal conduction and viscosity. Coefficients of diffusion, thermal conduction and viscosity. Molecular-kinetic theory of these phenomena.

RECITATIONS

1. Molecular physics and thermodynamics

LABORATORY EXPERIMENT FOR UNIT 2

1. Heat capacities ratio measurements.

Each student has to conduct this experiment if the instructor assigns it.

UNIT 3: Electricity

LECTURES

Topic 11. Electrostatic field in vacuum.

Electromagnetic interaction. Law of conservation of electric charge. Coulomb's law for vacuum and medium.

Electric field. Electric field of a point charge. Electric field lines. Principle of superposition of electrostatic fields. Field of an electric dipole, an electric dipole moment. Dipole in a uniform and non–uniform electric field.

Topic 12. Gauss's Law.

Electric flux. Gauss's law for electrostatic field in vacuum. Application of Gauss's law for calculation of electric field and potential for uniformly charged: sphere, infinitely long, thin wire and cylinder, infinite plane.

Topic 13. Electric Potential.

Work done in the electric field. Potential of the electric field. Relationships between electric field and potential, potential (potential differences) and electric field. Conductors in electric field. Electric field inside conductors and on their surfaces. Distribution of charges and potential over the conductors. Electric wind. Electrostatic screening and earthing. Lightning protection.

Topic 14. Electrostatic field in a medium. Capacitance

Electric capacitance of an isolated conductor. Mutual capacitance of two conductors. Capacitors and their capacitance. Capacitance of parallel-plane, cylindrical and spherical capacitors. Effective capacitance of capacitors connected in series and in parallel. Energy of charged conductor and capacitor. Energy of electrostatic field. Volume energy density of electrostatic field.

Electrostatic field in medium. Free and bound electric charges in dielectric. Types of dielectrics. Electron and orientational polarization, polarization of ions. Polarization vector. Relationship between polarization and the electric field. Dielectric susceptibility. Relationship between polarization and the induced surface charge density. Vector of electric displacement. Relation between $\vec{D}$, $\vec{E}$ and $\vec{P}$. Dielectric permittivity of a medium. Gauss's law for electric displacement in the integral and differential forms.

. Gauss's law in differential form. Divergence of vector. Laplace and Poisson equations. Principal problem of electrostatic and the scheme of its solution.

Topic 15. Electric Current. DC Circuits.

Electric current. Current density. Classical theory of electrical conductivity in metals. Ohm's laws in differential form. Resistivity. Temperature dependence of resistivity.

Ohm's law in integral forms. Resistance. Effective resistance of resistors connected in series and in parallel. Electric power. Electromotive force (EMF). Complete circuit. Forked circuits. Kirchhoff's junction and loop rules. ***RC***- circuits**.**

RECITATIONS

1. Electric field in vacuum.
2. Gauss's Law.
3. Electric Potential.
4. Electric capacitance. Energy of electric field.
5. Electric current. DC circuits.

LABORATORY EXPERIMENTS: UNIT 4

1. Electrostatic field modeling method.
2. Capacitance measurements.
3. Capacitor's charging and discharging.
4. EMF measurements

Each student has to conduct two experiments from the list according to instructor assignment.

Self-training

Electric current in liquid and gas. Faraday's laws of electrolysis. Electroconductivity of gases. Gas discharge of different types. Plasma. Electric current in vacuum. Thermoelectric emission. Work function of electron in metal.

UNIT 4: Magnetism

LECTURES

Topic 16. Effect of the Magnetic Fields.

Motion of charged particles in magnetic field. Magnetic field vector ($\vec{B}$). Magnetic force on a current-carrying conductor.

Loop with current in a magnetic field. Torque on the loop with current in a uniform magnetic field. Loop with current in a non–uniform magnetic field. Magnetic moment of the loop with current.

Velocity selector and mass-spectrometer. Principle of operation of cyclotrons. Hall effect. MGD – generator.

Topic 17. Sources of the Magnetic Field.

Magnetic field of a moving charge. Interaction force between two moving charged particles. Magnetic effect as a relativistic phenomenon.

Magnetic field of a current element. Biot and Savart law. Magnetic field lines and their peculiarities. Magnetic field of a straight current-carrying conductor. Magnetic field of a circular current loop.

Ampere's law (theorem of circulation of $\vec{B}$) for magnetic field in vacuum. Magnetic field of a solenoid and toroid. Interaction force between the conductors. Definition of the ampere.

Topic 18. Faraday's Law.

Magnetic flux. Work done by a magnetic field force on a conductor and loop with current. Gauss law for Magnetic field. Electromagnetic induction phenomenon. Faraday's law of induction. Lenz's law. Motional EMF in the moving rod in the magnetic field. EMF induced by rotation of a conducting loop in a magnetic field. Induced (nonconservative) electric field. Eddy currents.

Topic 19. Magnetic field in medium. Inductance.

Magnetic field in a medium. Micro– and macro–currents. Magnetic moments of atoms. Magnetization. Magnetic field intensity. Relation between $\vec{B}$ and $\vec{H}$.

Types of magnetics. Theory of dia– and paramagnetism. Magnetic susceptibility and its dependence on temperature. Ampere law in medium. Magnetic permeability. Ferromagnetics. Magnetization curve. Magnetic hysteresis. Domain. Curie point. Spin nature of ferromagnetism.

Self– induction phenomenon. Inductance of infinitely long solenoid. ***RL*** circuits. Energy of magnetic field of solenoid. Volume energy density of magnetic field.

Topic 20. Electrical oscillations and AC circuits.

Electromagnetic oscillations in LC circuit. Electromagnetic oscillations in RLC. Forced oscillations. Resonance.

Topic 21. Maxwell's Equations. Electromagnetic waves.

Displacement current. System of Maxwell's equations in differential and integral forms.

Electromagnetic waves in vacuum. Properties of EMW. Energy of EMW. Momentum of EMW. Pressure due to EMW. Volume density of energy flow. Pointing vector.

RECITATIONS

1. Effects of Magnetic Fields.
2. Sources of the Magnetic Field
3. Faraday's. Law
4. Inductance. Magnetic Field in a Medium.
5. Maxell's Equations.

Self-training

Current and voltage resonance. Herz experiments. Maxwell's rainbow. Radiation from dipole. Use of EMW in science and engineering.

LABORATORY EXPERIMENTS: UNIT 4

1. Electron specific charge.
2. Magnetic field of a coil.
3. Faraday's law.
4. Magnetic inclination.

5. Self-induction phenomenon

Each student has to conduct two experiments from the list according to instructor assignment.

UNIT 5: Wave Optics and Modern Physics

LECTURES

Topic 22. Interference of light.

Interference of light. Monochromatic and coherent light waves. Methods of obtaining of coherent waves. Conditions for destructive and constructive interference. Optical path difference. Interference pattern due two coherent sources of light. Young double-slit experiment. Newton's rings. Interference in thin films. Interferometers.

Topic 23.Diffraction of light.

Diffraction of light and its condition. Huygens–Fresnel's principle. Method of Fresnel's zones. Radius of Fresnel's zones. Vectors' diagram for calculation of resultant amplitude. Fresnel's diffraction from a circular aperture. Fraungoffer's diffraction from single slit and diffraction grating. Resolving power of optical instruments. X-rays and methods of their acquisition. X-rays diffraction. Bragg law. X-ray crystallography.

Topic 24. Absorption, Polarization, and Dispersion.

Absorption of light. Buger's law. Polarization of light. Natural and polarized light. Polarization of light at reflection. Bruster's law. Analysis of polarized light. Malus's law. Optically non-uniform medium. Polarization at scattering. Birefringence. Single axis crystals. Polaroids and polarizing prisms. Optically active crystals. Rotation of plane of polarization. Optical artificial anisotropy. Kerr's and Faraday's effects.

Dispersion of light. Normal and abnormal dispersion. Electron theory of dispersion.

Doppler effect. Vavilov-Cherenkov radiation.

Topic 25 Holography

Topic is assigned for self-training.

Topic 26. Elements of relativistic mechanics.

Galilean principle of relativity. Galilean transformation. Postulate of special theory of relativity. Lorentz transformation for space and time. Conception of simultaneity. Relativity of length and time interval. Interval between two events and its invariance relative to chosen frame of reference as a result of interrelation between space and time. Relativistic addition of velocities.

Relativistic momentum. Main law of relativistic dynamics. Relativistic expression for kinetics energy. Total rest energy. Einstein's mass-energy equivalence. Relation between total energy and momentum of the particle. Boundaries of the classical mechanics application.

Topic 27.Heat radiation.

Heat radiation. Emissivity and spectral emissivity of light. Absorbing power of a body. Black body. Kirhgoff's law for heat radiation. Stefan-Boltzmann's law. Distribution of energy over radiation spectrum of black body. Vien's laws. Quantum hypothesis and Plank's formula. Derivation of StefanBoltzmann's and Vien's laws from Plank's formula. Physical fundamentals of optical pyrometry.

Topic 28. Quantum optics.

Photons. Energy and momentum of photons.

External photoelectrical effect and its laws. Einstein's equation for external photoelectrical effect. Bothe's experiment.

Compton's effect and its theory. Pressure of light. Lebedev's experiments. Dialectical identical of corpuscular and wave properties of electromagnetic radiation.

Topic 29. Principles of quantum mechanics.

De-Brogle's hypothesis. Diffraction of electrons, protons and newtrons. Corpuscular-wave dualism of particles. Heisenberg's inequality of uncertainties as manifestation of corpuscular-wave dualism of microworld. Roundedness of mechanical determinism. Borh's principle of complementarily.

Wave function and its properties. Probability-statistical interpretation of wave function. Timedependent Schrödinger's equation. Stationary state. Schrödinger's equation for stationary states. Motion of free particles. Particle in a rectangular infinitely deep potential well. Quantization of particle's energy. Harmonical quantum oscillator. Zero quantum oscillations. Tunneling effect. Coefficient of transparency of potential barrier. Hydrogen atom. Quantization of energy. Space quantization. Quantum numbers: principal, azimuthal, magnetic.

Stern–Gerlah experiment. Spin of electron. Magnetic spin quantum number. Fermions and bosons. Exclusion Pauli's principle. Distribution of electrons over energy levels in atom.

Topic 30. Introduction to nuclear physics.

Charge, dimension and mass of atomic nucleus. Mass and charge number. Structure of nucleus. Classification of nuclei. Interaction between nucleons. Notion of properties and nature of nuclear forces. Radioactivity. Law of radioactive disintegration. Radioactive transformations of atomic nuclei. Activity of radioactive elements.

Nuclear reactions and laws of conservations. Bound energy and defect of mass. Reaction of nuclear fission and synthesis of nuclei. Chain reaction. Nuclear reactors.

RECITATIONS

1. Interference.
2. Diffraction.
3. Polarization.
4. Heat radiation.
5. Photons.
6. Principles of quantum mechanics
7. Introduction to nuclear physics.

LABORATORY EXPERIMENTS: UNIT 5

1. Interference of light
2. Diffraction of light
3. Polarization of light
4. Stefan-Boltzmann law
5. Photoelectric effect

Each student has to conduct two experiments from the list according to instructor assignment.

Self-training

Special theory of relativity. Radiation spectrum of atoms and molecules. Forbidden transitions.

Absorption of light. Spontaneous and forced radiation. Physical fundamentals of laser's operation. Ruby and helium-neon laser. Application of laser radiation.

Elements of band theory of solids. Notion of Fermi-Dirac's quantum statistics. Fermi's level. Energy band in crystals. Distribution of electrons over energy bands. Valence and conductivity bands. Metals, dielectrics and semiconductors in terms of energy bands. Intrinsic and impurity conductivity of semiconductors. Contact phenomenon.: metal-semiconductor contact. Electron and hole semiconductors, p-n transition.

Nuclear power engineering and ecological problems. Thermonuclear reactions. Energy of stars. Controllable thermonuclear synthesis.

5. Assessment methods

Assessment during the semester:

Laboratory experiments: 5 in each semester (once per two weeks);

Recitation: 5 problems each in class and in homework (once a week);

Midterm quizzes (MCQ) on units (2 in the 1st and the 2nd semester), held after class.

Assessment at the end of the semester:

final written exam as an opportunity to improve midterm results.

6. Assessment criteria

Laboratory experiments are up to 5 points for each report according to the scheme: up to 1 point for permission, 1 point for the measurements, 1 point for the calculations, up to 2 points for defense (answers to control questions). Total lab score rescaled up to 30 points.

Recitation classes are up to 30 points. For doing homework (problem solving) is up to 12 points, proportional to the ratio of the number of solved problems to the planned one. For work in the classroom during the term is up to 18 points. This score depends on the number of problems solved on the board and the quality of their solutions.

Midterm quizzes are in MCQ-format (off-line education mode) or open-question-format (on-line education mode). On UNITS 1, 3, 4 – 2 hours each, on UNIT 5 – 1 hour. All Midterm quizzes up to 20 points for each. Midterm quizzes are written after classes according to the schedule.

Student must perform all assigned laboratory experiments to have permission for the final assessment. The minimum required score for each recitation or laboratory experiment is 10. A passing score for the 1st semester is required for admission to the final assessment in the 2nd semester.

Total points for laboratory experiments, recitation classes and the results of midterm quizzes determine the score of the semester.

A student has the right to refuse the results of midterm quizzes and get a new grade during the final written exam. The maximum score for the final (3 hours) is equal to the sum of points for midterm quizzes during the semester, i.e. 40 points.

Maximum possible total score for the semester is 100 points.

7. Assessment scale

Total points for all types of assessments	Final grade in the traditional scale
90 – 100	Excellent
75 – 89	Good
60 – 74	Satisfactory
01 – 59	Unsatisfactory

8. Recommended Reading

1. Sears and Zemansky's University Physics: with modern physics.-12th ed./Hugh D. Young, Roger A. Freedman; contributing author, A. Lewis Ford. - Pearson Education, Inc., publishing as Pearson Addison-Wesley, 1301 Sansome St., San Francisco, CA 94111. – 2008 – 1621 pg.
2. Physics for Scientists and Engineers with Modern Physics. - Third ed./Paul M. Fishbane, Stephen G. Gasiorowicz, Stephen T. Thornton .– Pearson Prentice Hall Pearson Education. Inc., Upper Saddle River, New Jersey 07458. – 2005 – 1379 pg.
3. Physics for Scientists and Engineers with Modern Physics. – 8th ed./ Raymond A. Serway, John W. Jewett – Thomson Brooks/Cole. – 2010 – 1558 pg.
4. Physics for Engineers. Part V. Wave Optics. Textbook/ Ya. Karpov, O. Naumenko, and others. KhAI, 2008.-178pg.
5. Physics for Engineers. Part IV. Oscillations and Waves. Textbook/ O. Naumenko and others. KhAI, 2011.-264pg
6. Physics: Guidance manual for laboratory experiments/Okhrimovskyy A.M., Podshyvalova O.V. — Kharkiv: National Aerospace University “KhAI”, 2011. — 144pg.
7. Mechanics and Thermodynamics. Guidance manual for recitations/ Okhrimovskyy A.M., Podshyvalova O.V. . — Kharkiv: National Aerospace University “KhAI”, 2012. — 72pg.
8. Electricity and Magnetism: guidance manual for recitation /A. M. Okhrimovskyy, O. V. Podshyvalova, S. V. Oliinyk. — Kharkiv: National Aerospace University “KhAI”, 2013. — 116 pg.
9. Wave Optics and Modern Physics: guidance manual for recitation / A. M. Okhrimovskyy, O. V. Podshyvalova, D. O. Voronovich. — Kharkiv: National Aerospace University “KhAI”, 2014. — 80 pg.

8. Complementary Reading

1. Савельев И.В. Курс физики (Учеб. для втузов) Т1:Механика. Молекулярная физика.- М. :Наука, 1987.- 432 с. Б(567), К(19).
2. Савельев И.В. Курс физики (Учеб. для втузов) Т2: Электричество и магнетизм. Волны, Оптика- М.:Наука, 1988.- 432 с. Б(588), К(18).
3. Савельев И.В. Курс физики (Учеб. для втузов) Т3:Квантовая оптика. Атомная физика. Фізика твердого тела. Физика атомного ядра и элементарных частиц.- М.:Наука, 1989.- 304с. Б(225), К(12).
4. Яворский Б.М., Пинский А.А. Основы физики, Уч. пос. Т1 Механика. Молекулярная физика. Электродинамика. М., Наука, 1981.- 480с. Б(7), К(0).
5. Яворский Б.М., Пинский А.А. Основы физики, Уч. пос. Т2. Колебания и волны. Основы квантовой физики атомов, молекул и твердых тел; Физика ядра и элементарных частиц.- М., Наука, 1974.- 464с. Б(16), К(3)
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