Ministry of Science and Higher Education of the Russian Federation
Federal State Autonomous Educational Institution of Higher Education
Perm National Research Polytechnic University

APPROVED BY
Pro-rector for Academic Affairs
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ACADEMIC COURSE WORKING PROGRAM

Academic course: Physics
(Name)

Form of education: Full-time
(full-time / part-time / correspondence)

Level of higher education: Bachelor's program
(Bachelor's program / Specialist program / Master's program)

Total labour intensiveness: 324 (9)
(Hours (CU))

Training program (degree): 15.03.06 Mechatronics and Robotics
(Code and denomination of degree)

Direction: Mechatronics and Robotics
(Title of curriculum)

Perm 2021

1. General Provisions

1.1 Goals and Objectives of the Course

The purpose of the course is to:
• study physical phenomena and physical laws, their limits, implementation in the most important practices;
• know basic physical quantities, their definition and meaning, methods and units of their measurement;
• be aware of fundamental physical experiments and their role in science development;
• know the purpose of the most important physical devices and their work mechanisms;
• have skills of using modern scientific devices and equipment;
• have skills of using various methods of physical measurement and data processing; physical and mathematical modeling; physical and mathematical analysis to solve specific natural science and technical problems;
• understand the connections between sections of physics courses,
• develop an idea, that physics is a universal basis for technical sciences, and that those physical phenomena and processes that are still limitedly applied in technology, in the future may find themselves in the center of pioneering engineering excellence.

1.2 Prescribed Objects of the Course

•physical phenomena and processes in nature and technological systems;
•laws describing physical phenomena and processes;
•instruments to study physical systems;
•methods to research physical systems;
•methods of physical systems formalized description, including mathematical and computer modeling means.

1.3 Starting Conditions

Unstipulated

2. Planned Results of the Course Training

Competence	Indicator's Index	Planned Results of the Course Training (to know, to be able to, to master)	Indicator of Attaining Competence which the planned results of training are correlated with	Means of Assessment
GPC-2	**IA-1$_{gpc-2}$**	**To know**: -basic physical laws and phenomena, and their application limits; - main physical quantities and physical constants, their definition, meaning, and ways to measure them; - basic methods of physical examination, including fundamental physical experiments and their role in the	**Knows** principles of local and wide area networks construction, fundamentals of IT, common procedures of problem-oriented software application.	Test

		science development; - purpose and operating principle of the most important physical instruments devices, measurement tools; - methods to solve physical tasks, corresponding to professional activities.		
GPC-2	**IA-2$_{gpc-2}$**	**To be able to**: - indicate which laws describe this phenomenon or effect; -highlight physical content in applied tasks; -search and organize information; - interpret the meaning of physical quantities and concepts; - write equations for physical quantities in SI system; - use basic models, concepts, and laws; -apply them addressing practical tasks; - apply physical and mathematical analysis to solve applied tasks; -use proper methods of physical and mathematical modeling; - calculate with application software tools.	**Is able to** use modern information and computer technology, means of communication promoting efficiency improvement of scientific and educational activity.	Individual task
GPC-2	**IA-3$_{gpc-2}$**	**To master the skills of:** - using basic physical laws and principles in critical practice iCal applications; -solving typical tasks; -applying basic methods of physical and mathematical analysis and formalization to solve practical tasks and find necessary information; - conducting scientific and technical	**Has mastered the skill** of mastering modern and advanced directions of engineering, progressive native and foreign experience in conducting research, design work, organization of technological processes and maintenance of mechatronic and robotic systems and/or their components.	Presenting laboratory work

		experiments; -processing, analyzing, and processing results of experiments; - mathematical modeling in engineering practice, analysis and interpretation of its results, using applied software tools.		
GPC-8	**IA-1$_{gpc-8}$**	**To know**: - basic physical quantities and physical constants, their definition, meaning, ways to measure them; - purpose and operating principle physical instruments, measurement and control tools.	**Knows** methods of costs optimization for ensuring the production activities of engineering enterprises' divisions.	Test
GPC-8	**IA-2$_{gpc-8}$**	**To be able to**: - indicate which laws describe this phenomenon or effect; -extract physical content in applied tasks; -search and organize information; - work with physical devices and equipment; - used different measurement techniques; -process and interprete experimental data.	**Is able to** apply economic methods of reducing costs in engineering production.	Individual task
GPC-8	**IA-3$_{gpc-8}$**	**To master the skills of:** - using the main instruments and equipment in modern physical laboratories; - conducting scientific and technical experiment; -processing, analyzing, and interpreting experimental data; - searching, selecting, organizing, analyzing, and processing	**Has mastered the skills** of using tools and methods to optimize the costs of conducting specialized production activities.	Presenting laboratory work

		scientific and technical information; -interpreting and representing in the form of texts, tables, graphs, charts.		

3. Full time and forms of academic work

Form of academic work	Hours in all	Distribution in hours according to semesters	
		Number of semester	
1 Holding classes (including results monitoring) in the form: 1.1 Contact classwork, including:	120	60	60
- lectures (L)	48	24	24
- laboratory work (LW)	36	18	18
- practice, seminars and/or other seminar-type work (PW)	32	16	16
- control of self-work (CSW)	4	2	2
- test			
1.2 Students' self-work (SSW)	168	84	84
2 Intermediate attestation			
Exam	36	36	
Grading test	9		9
Test (Credit)			
Course Project (CP)			
Course Work (CW)			
Workload in hours	**324**	**180**	**144**

4. Course contents

Name of the units with the course outline	Full time of classroom activity in hours according to the forms			Full time of extracurricular work in hours according to the forms
	L	LW	PW	SSW
2nd semester				
Mechanics	8	6	6	30
Topic 1. Kinematics. Basic kinematic characteristics. Straight and curved movement: speed and acceleration. Normal and tangential acceleration. Rotational kinematics: angular velocity and angular acceleration, their relationship with linear speed and acceleration. Direct and inverse problem of kinematics. The laws of uniform and equal motion. **Topic 2.** Dynamics of translational motion. Inertial frames of reference and the first law Newton. Newton's second law. Mass, impulse, force. Equation of motion of a material point. Newton's third law and the law of conservation of momentum. The law of universal gravitation. Elastic forces and friction. **Topic 3.** Dynamics of rotational motion. Moment of				

momentum of a material point and mechanical system. Moment of power. The equation moments. The law of conservation of angular momentum mechanical system. The basic law of dynamics rotational motion of a rigid body with a fixed axis of rotation. Body momentum. Moment of inertia. Steiner's theorem. **Topic 4.** Work (mechanical power). Energy. Strength, mechanical and potential energy. Conservative and non-conservative forces. Work and kinetic energy for translational and rotational motion. Complete conservation law mechanical energy in the field of potential forces. Collisions of bodies. Absolutely elastic collision. **Topic 5.** Elements of continuum mechanics. General properties of liquids and gases. Ideally elastic body. Elastic stresses and deformations. Hooke's Law. Young's modulus.				
Oscillations and waves	6	4	4	20
Topic 6. Kinematics of vibrations. Amplitude, frequency and phase of oscillations. Law harmonic vibrations; their image on graphs and vector diagrams. Addition vibrations (beats, Lissajous figures). Decomposition and synthesis of vibrations. Vector description of addition hesitation. **Topic 7.** Dynamics of fluctuations. Perfect harmonic oscillator. Quasi-elastic force. The equation of an ideal oscillator and its solution. Pendulums. Energy transformations at fluctuations. Free damped oscillations lossy oscillator. Forced vibrations. Resonance. **Topic 8.** Waves. Wave motion. Plane harmonic wave. Wavelengths, wavenumber, phase velocity. Wave equation. One-dimensional wave equation. Elastic waves. Wave interference. Standing waves. Wave equation in space.				
Statistical physics and thermodynamics	4	2	2	10
Topic 9. Molecular kinetic theory. Ideal gas state parameters. Gas pressure from the point of view of MKT. Equal distribution of energy molecules by degrees of freedom. The equation fortunes ideal gas. Laws for isoprocesses. Root mean square speed. Distribution Maxwell for the modulus and projections of the velocity of molecules ideal gas. Experimental justification Maxwell distribution. Boltzmann distribution and barometric formula. **Topic 10.** Phenomenological thermodynamics. Thermodynamic equilibrium and temperature. Zero principle of thermodynamics. Empirical temperature scale. Quasi-static processes. Reversible and irreversible processes. Energy molecules, the internal energy of an ideal gas. The first law of thermodynamics. Heat capacity. Mayer's equation. Isochoric, isobaric, isothermal, adiabatic processes in ideal gases. Converting heat to mechanical work. The				

Carnot cycle and its efficiency. Entropy. **Topic 11.** Elements of physical kinetics. Transfer phenomena. Diffusion, thermal conductivity, internal friction. Brownian motion.				
Electrostatics and direct electric current	6	6	4	24
Topic 12. Electric field in vacuum. Coulomb's law. Electrostatic tension fields and the principle of superposition. Work on moving a charge in an electric field. Potential energy, potential. Difference potentials. Gauss's theorem in integral form Topic 13. Conductors in an electric field. Equilibrium of charges in a conductor. Equipotential surfaces and lines of force electrostatic field between conductors. Electrostatic protection. The capacitance of the conductors and capacitors. Energy of a charged condenser. **Topic 14.** Dielectrics in an electric field. Dipole electric field. Dipole in the external electric field. Polarization of dielectrics. Orientation and deformation mechanisms polarization. Electrical displacement vector (electrical induction). Dielectric substance permeability. Electric field in homogeneous dielectric. **Topic 15.** Constant electric current. Strength and current density. Ohm's law differential and integral forms. Law Joule-Lenz. Source electromotive force current. Kirchhoff rules.				
Total with regard to 2nd semester	24	18	16	84
3rd semester				
Magnetism	4	4	4	12
Topic 16. Magnetostatics. Magnetic interaction of direct currents. Vector of magnetic induction. Bio-Savard's Law Laplace. Lorentz force. Ampere's law. Traffic charges in electric and magnetic fields. Magnetic flux and Gaussian theorem for magnetic fields. Circulation theorem (total current law). **Topic 17.** Magnetic field in matter. Magnetic field and magnetic dipole moment circular current. Magnetization of magnets. Magnetic field strength. Magnetic permeability. Classification of magnets. Ferromagnetism. **Topic 18.** Electromagnetic induction. Phenomenology of electromagnetic induction. Lenz's rule. Electromagnetic equation induction. Self-induction. Mutual induction. Solenoid inductance. The energy of the magnetic field. **Topic 19.** Electromagnetic vibrations. Harmonic oscillations in the circuit. Energy processes in the loop. Ox is a new resistance. Damped oscillations in the circuit. Reactive (capacitive and inductive) resistance. Attenuation characteristics. Forced vibrations in a serial loop. Resonance. Resonant curves for charge, voltage, current. **Topic 20.** Maxwell's equations. The system of Maxwell equations in integral form and the physical meaning of its equations.				

Topic 21. Electromagnetic waves. Plane and spherical electromagnetic waves. Right triplet of vectors E, B, v. Wave equation. Polarization of waves.				
Optics	6	6	6	18
Topic 22. Interference. Interference field from two point sources. Jung's experience. Interference in thin films. Topic 23. Diffraction. Huygens-Fresnel principle. Fresnel diffraction on the simplest barriers. Fraunhofer diffraction. Diffraction grating as a spectral device. **Topic 24.** Polarization. The shape and degree of polarization of monochromatic waves. Obtaining and analyzing linearly polarized radiation. Malus' law. Brewster's Law. **Topic 25.** Absorption and dispersion of waves. Phenomenology of absorption and dispersion of light.				
The quantum physics	7	4	4	22
Topic 26. Quantum properties of electromagnetic radiation. Radiation from heated bodies. Spectral thermal radiation characteristics. The laws Kirchhoff, Stefan-Boltzmann and Wien. Absolutely black body. Planck's conjecture. Quantum explanation laws of thermal radiation. Corpuscular wave dualism of light. The phenomenon of the photoelectric effect. Einstein's equation for the photoelectric effect. **Topic 27.** Planetary model of the atom. Thomson's model of the atom. Rutherford's experiments on scattering of alpha particles. Nuclear model of the atom. Empirical patterns in atomic spectra. Balmer's formula. Bohr's model of the atom. Scheme energy levels in the hydrogen atom. **Topic 28.** Quantum mechanics.Wave-corpuscle dualism. Hypothesis de Broglie. Experiments by Davisson and Jermer. Diffraction microparticles. The uncertainty principle Heisenberg. Wave function, its statistical meaning and conditions that it should satisfy. **Topic 29.** Quantum-mechanical description of atoms. Stationary Schrödinger equation for the atom hydrogen. Wave functions and quantum numbers. Selection rules for quantum transitions. **Topic 30**. Optical quantum generators. Spontaneous and induced emission. Inverse populating the levels of the active environment. The main laser components. Condition of amplification and generation radiation. Features of laser radiation. The main types of lasers and their applications. **Topic 32.** Elements of solid state physics. Band structure in metals, semiconductors and dielectrics. Conductivity of metals. Own and impurity conductivity of semiconductors. Fermi level in pure and impurity semiconductors. Diodes. Locking layer in semiconductors.				
Nuclear physics. Physical picture of the world	3	1	0	4

Topic 33. Fundamentals of the physics of the atomic nucleus.The composition of the atomic nucleus. Core characteristics: charge, mass, binding energy of nucleons. Radioactivity. Types and laws of radioactive radiation. Nuclear reactions. Fission of nuclei. Synthesis of nuclei. Detection of nuclear radiation. Concept of dosimetry and protection. **Topic 34.** Elementary particles. Fundamental interactions and major classes of elementary particles. Hours and antiparticles. Leptons and hadrons. Quarks. Electroweak interaction. **Topic 35.** Physical picture of the world. Features classic, non-classical and modern physics. Methodology of modern research programs in physics. Major achievements and challenges subnuclear physics. Attempts to unite fundamental interactions and creation "Theory of everything." Modern cosmological representation. Changes in technique and technology as a consequence of scientific advances in physics. The physical picture of the world as a philosophical category. Newton's paradigm and evolutionary paradigm.				
Total with regard to 3rd semester	**24**	**18**	**16**	**84**
Total with regard to the course	**48**	**36**	**32**	**168**

Topics of exemplary practical works

№	Topic of practical works
1	Kinematics and dynamics of a material point and progressive motion
2	Work, power, energy
3	Rotational dynamics
4	Oscillatory and wave motion
5	Molecular kinetic theory of matter
6	The laws of thermodynamics
7	Electrostatic field in vacuum
8	Electrostatic field in dielectrics and conductors. Gauss's theorem
9	Constant electric current
10	Magnetic field in vacuum
11	Electromagnetic induction
12	Electromagnetic vibrations
13	Light interference
14	Light diffraction
15	Light polarization
16	Heat radiation. Photoeffect

Topics of exemplary laboratory works

№	Topic of laboratory works
1	Estimating cylinder volume.
2	Oberbeck's pendulum
3	Physical pendulum
4	Determining gravity acceleration by the method of a revolving physical pendulum
5	Studying free vibrations of a spring pendulum

6	Determining fluid viscosity by Stokes method
7	Exploring an electronic oscilloscope
8	Studying electrostatic fields
9	Determining electromotive force and internal resistance of the current source
10	Studying dependence of current source's power and efficiency on load
11	Determining magnetic induction in the pole gap of the magnetoelectric system device
12	Investigating magnetic field of circular current
13	Determining induction vector components of the of the Earth's magnetic field using a cathode-ray tube
14	Studying the phenomenon of hysteresis using an electronic oscilloscope
15	Studying damped oscillations in a circuit
16	Studying forced vibrations in a series circuit
17	Determining refractive index of solids using a microscope
18	Fresnel biprism
19	Interference of laser light when reflected from a thick glass plate
20	Determining wavelength of light using a diffraction grating
21	Determining polarization degree of a laser beam. Study of Malus' law and Brewster's law
22	Photocell research
23	Estimating Stefan-Boltzmann constant using a disappearing filament pyrometer
24	Studying the dependence of semiconductors electrical resistance on temperature
25	Studying the dependence of metals electrical resistance on temperature

5. Organizational and Pedagogical Conditions

5.1 Educational Technologies Used for Competences Formation

Holding lectures in the discipline is based on the active method of training in the process of which students are not passive but active participants of the lesson answering questions of the teacher. Teacher's questions are aimed at activating the process of learning material as well as at the development of logical thinking. The questions stimulating associative thinking and connecting new material with the previous one are formulated by the teacher in advance.

Practical lessons are held by realization of the method based on active training: problem areas are determined, groups are formed. The following aims are pursued in the process of practical education: use of definite disciplines knowledge and creative methods in solving problems and decision-making; students' skill-building of teamwork, interpersonal communication and development of leadership skills; consolidation of the basic theoretical knowledge.

Laboratory classes are based on an interactive learning method in which students communicate not only with the teacher but also with each other. At the same time, students' activity in the learning process dominates. The teacher's place in interactive classes is reduced to orienting students' activities to achievement of the goals of studies.

Interactive lectures, group discussions, role-playing games, training sessions, and analysis of situations and simulation models are used in academic studies.

5.2 Students' Manual for the Course Study

Learning the course, it is advisable for students to implement the following recommendations:

1. Learning of the discipline should be done systematically.
2. After learning one of the course units with the help of the text-book or lecture notes it is recommended to reproduce the basic terms, definitions, notions of the unit from memory.
3. Special attention should be paid to the reports on practical studies and individual complex tasks for self-work.
4. The topics list for individual study is given by the teacher at the lectures. The teacher also provides students with literary sources (first of all, new ones in the periodical scientific literature) for a more detailed under-standing of the issues presented at the lectures.

6. List of Teaching Materials and Information Supply for Students' Self work in the Discipline

6.1 Paper-based courseware

№	Bibliographic entry (author, title, mode of publication, place, publishing house, year of publication, number of pages)	Number of copies in the library
	1 Basic literature	
1		
	2 Additional literature	
	2.1 Educational and scientific literature	
1	Physics of Narrow Gap Semiconductors. Proceedings of the III International Conference, Warszawa, September 12-15, 1977, Warszawa : PWN - Polish Scientific Publ., 1978	3
2	Laboratory Manual for Physical Geology, Dubuque : WCB, 1995	
	2.2 Periodical and Technical literature	
	Physical Review. American Physical Society (United States), 1893–2020.	-
	3 Students' manual in mastering discipline	
	4 Teaching and learning materials for students' self-work	
	Kampf G. Characterization of plastics by physical methods. Munich : Hanser, 1986	5

6.2 Electronic Courseware

Kind of literature	Name of training tool	Reference to information resource	Accessibility of EBN (Internet / local net; authorized / free access)
Additional literature	Journal of Physics G: Nuclear and Particle Physics	https://iopscience.iop.org/journal/0954-3899	internet, free access

6.3 License and Free Distributed Software used in the Course Educational Process

Type of Software	Software branding
Operating systems	Windows 10 (Azure Dev Tools for Teaching)
Office applications	Microsoft Office Professional 2007, license 42661567

6.4 Modern Professional Databases and Inquiry Systems Used in the Course Educational Process

Branding	Reference to information resource
Scientific electronic library database (eLIBRARY.RU)	https://elibrary.ru/
Scientific Library of Perm National Research Polytechnic University	http://lib.pstu.ru/
Electronic library system IPRbooks	http://www.iprbookshop.ru/
Lan' Electronic library system	https://e.lanbook.com/
Information resources of the Network ConsultantPlus	http://www.consultant.ru/

7. Logistics of the Course Educational Process

Type of classes	Name of the necessary basic equipment	Number of units
Laboratory class	laboratory stand "Mechanics"	15
Laboratory class	laboratory stand "Optics"	15
Laboratory class	laboratory stand "Electromagnetism"	15
Lecture	Projector, laptop	1
Practical class	Personal computer	1

8. Fund of the Course Evaluating Tools

Described in a separate document