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, special chapters
(Name)

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

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

Workload in hours (in credits): 108 (3)
(Hours (CU))

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

Direction: Mechatronics and Robotics
(Title of curriculum)

Perm 2020

1. General Provisions

1.1.Goals and Objectives of the Course

The goal of the course is:

- to study physical phenomena and the laws of physics, the limits of their application, practical application of laws; to get acquainted with the basic physical quantities, to know their definition, meaning, methods and units of their measurement; to carry out fundamental physical experiments and to understand their role in the science development; to know the purpose and principles of physical devices operation;
- to develop skills of working with modern physical instruments and equipment; skills of using various methods of physical measurement and processing the experimental data; skills of physical and mathematical modeling, skills of physical and mathematical analysis to solve scientific and technical problems;
- to understand the logical connection between the course parts, to develop the knowledge of physics as a universal basis for the technical sciences, to promote the idea that physical phenomena and processes limitedly applied in technology may in the future be at the center of innovative engineering achievements.

As a result of studying the discipline the student
knows:
- basic physical phenomena and processes which the principles of objects action are based on, areas and possibilities of using physical effects;
- fundamental concepts, laws and theories of classical and modern physics, the limits of basic physical models application;
- basic physical quantities and constants, their definitions and units of measurement;
- methods of physical research, including methods of physical modeling processes;
- methods of solving physical problems significant for technical application;
- physical foundation of measurements, methods of measuring physical quantities;
- technologies for working with various types of data;

is be able to:
- allocate physical content in systems and devices of different physical nature;
- carry out a correct mathematical description of physical phenomena in technological processes;
- build and analyze mathematical models of physical phenomena and processes solving applied problems;
- solve typical problems in the main sections of physics, using the methods of mathematical analysis and modeling;
- apply concepts, physical laws and methods of technical calculations, analyzing and solving practical problems, conducting research in professional activities;
- use modern physical equipment and devices in solving practical problems, to use the basic techniques for evaluating the error and processing experimental data;

has mastered the skills of:
- analysis methods of physical phenomena in technical devices and systems;
- skills in practical application of physical laws, including the products and processes design;

- theoretical research methods of physical phenomena and processes, construction of mathematical and physical models of real systems, solving physical problems;
- using basic physical devices;
- experimental physical research methods (planning, installation and processing of experimental data, including standard software packages);
- applying knowledge in physics to study other disciplines.

1.2. Studied Objects of the Course

Physical phenomena and processes in natural and human-made systems;
• Physical laws describing the phenomena and processes;
• Instruments for studying physical systems;
• Methods of physical systems research;
• Methods of physical systems formalized description, including mathematical and computer modeling.

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-1	**IA-1$_{gpc-1}$**	To know the mathematical formalization of fundamental physical laws in homogeneous and inhomogeneous media, including the laws of heat conduction, diffusion, fluid dynamics, filtration of liquids and gas.	Knows the ways to solve problems related to professional activities, applying methods of modeling, mathematical analysis, natural science and general engineering knowledge.	Interview
GPC-1	**IA-2$_{gpc-1.}$**	To be able to formulate and solve applied physical problems in the study of physical processes in mining.	**Is able to** solve problems related to professional activities, applying methods of modeling and mathematical analysis, to natural science and general engineering knowledge.	Individual task

GPC-1	**IA-3$_{gpc-1.}$**	To master the skills of applying physical methods for solving problems in the study of physical processes in mining.	**Has mastered** the skills of solving problems related to professional activities, applying methods of modeling and mathematical analysis, to natural science and general engineering knowledge.	Test
GPC-4.	**IA-1$_{gpc-4.}$**	To know the ways of processing and presenting the results of solving applied physical problems.	**Knows** how to make measurements and observations, process and present the experimental data.	Interview
GPC-4.	**IA-2$_{gpc-4.}$**	To be able to analyze and present the results of solving applied physical problems.	**Is able to** measure and observe, process and present the experimental data.	Individual task
GPC-4.	**IA-3$_{gpc-4.}$**	To master physical methods for solving applied problems in the study of physical processes in mining.	**Has mastered** the skills of making measurements and observations, processing and presenting the experimental data.	Test
GPC-7.	**IA-1$_{gpc-7.}$**	To know the main methods of solving applied problems in extraction, processing of minerals and the construction of underground structures.	**Knows** how to analyze, compile and apply technical documentation related to professional activities according to the applicable regulatory acts.	Interview
GPC-7.	**IA-2$_{gpc-7.}$**	To be able to analyze and formalize condition tasks.	**Is able to** analyze, compile and apply technical documentation related to professional activities according to the applicable regulatory acts.	Individual Task
GPC-7.	**IA-3$_{gpc-7.}$**	To master the skills of analyzing the physical problem and presenting its solution according to the norms of technical documentation.	**Has mastered** the skills of analyzing, composing and applying the technical documentation related to professional activities according to the applicable regulatory acts.	Test

3. Full time and forms of academic work

Form of academic work	Hours in all	Distribution in hours according to semesters
		Number of semesters
		7
1. Holding classes (including results monitoring) in the form: 1.1.Contact classwork, including:	45	45
- lectures (L)	16	16
- laboratory work (LW)		
-practice, seminars and/or other seminar-type work (PW)	27	27
- control of self-work (CSW)	2	2
- test		
1.2. Students' self-work (SSW)	63	63
2. Intermediate attestation		
Exam		
Grading test		
Test (Credit)	9	9
Course Project (CP)		
Course Work (CW)		
Workload in hours	**108**	**108**

4. Course outline

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
Semester 7				
Equations of mathematical physics	8	0	13	32
The main equations types of mathematical physics: parabolic, hyperbolic and elliptic types. Formulation of the problem. Non-stationary heat conduction processes. Cooling (heating) unlimited plate. Variable separation method - Fourier method. Simplification of the solution. Dimensionless form. Analysis of the solution. The amount of heat given off by the plate at cooling. Lagrange interpolation polynomials. Stationary thermal conductivity. Heat transfer through a flat wall. Boundary conditions of the first kind, the third kind. Stationary thermal conductivity in a ball, taking into account internal heat sources. Derivation of the heat conduction equation for the spherically symmetric case. Calculation of the temperature field. Thermal conductivity in a bar (rib) of constant cross-section. Rod of infinite and finite length. Hyperbolic functions. Cooling (heating) bodies of finite dimensions. Solution multiplication theorem. Wave equation. Transverse vibrations of a string fixed at the ends. Fourier method.				

Fourier expansion of functions. Fourier integral. Problems leading to the Laplace's equation. Laplace's equation in cylindrical coordinates. Integral Laplace transform. Table of originals and images. Solution of differential equations using operational calculus. Method of indefinite coefficients. Free damped and undamped oscillations. Solutions using the Laplace transform. Forced vibrations. Solution using the Laplace transform. Oscillatory circuit (C, L, R). Solution for the charge dependence on the capacitor and the current strength on time. Approximate solution of a differential equation using the Taylor and Maclaurin series.				
Mechanics and thermodynamics of liquids and gas.	8	0	14	31
Equations of incompressible viscous fluid motion. Some exact solutions of the viscous incompressible fluid motion equations. The steady fluid motion between parallel planes in the Couette flow. Velocity profile and flow rate. The fluid movement in a round tube in Poiseuille flow. Parabolic velocity profile. Volumetric flow rate and average velocity. Reynolds number. Hydrodynamic stabilization section. Hydraulic radius for pipes with complex cross-sectional profiles. Free convection equations in the Boussinesq approximation. Convective flow in a vertical layer. Problem statement and solution. Hyperbolic functions. Change in entropy while measuring the body temperature with a thermometer. Bodies fall of variable mass. Evenly evaporating drop of water. Stokes resistance force. Bullet movement inside the substance. Ball in liquid. Determination of the pressure force on the lower half of the ball's surface. Equation derivation of state for an ideal gas with the proportionality of heat capacity to temperature.				
Total with regard to 7th semester	16	0	27	63
Total with regard to the Course	16	0	27	63

Topics of exemplary practical work

Sl. №	**The topics of practical (seminar) work**
1	The problem of cooling a plate. Temperature distribution and heat loss. Lagrange interpolation polynomials.
2	Stationary thermal conductivity in a ball with internal heat sources. Thermal conductivity in a bar (rib) of constant cross-section. Rod of infinite and finite length. Hyperbolic functions.
3	Cooling (heating) bodies of finite dimensions. Example of a parallelepiped.
4	Free damped and undamped oscillations. Solutions using the Laplace transform.
5	Forced vibrations. Solution using Laplace transform.
6	An approximate solution of a differential equation using the Taylor and Maclaurin series.
7	The bodies fall of variable mass. Evenly evaporating drop of water. Stokes resistance force. Finding the movement speed dependence on time.

8	Ball in liquid. Determination of the pressure force on the lower half of the ball surface.
9	Sliding a bar over a rough surface. Braking time in case of partial and complete collision on a rough area. Examples for different values of the friction coefficient.
10	Equation derivation of state for an ideal gas with the proportionality of the heat capacity to temperature.
11	Change calculation in the internal energy of the nitrogen mass during quasi-static adiabatic expansion from the volume V1 at normal pressure p1 to the volume V2.
12	Study of measuring the thermophysical characteristics of solids by the quasi-linear method.
13	Study of an explicit scheme for calculating temperature fields. Sequential relaxation method. Isothermal boundaries
14	Study of an implicit scheme for calculating temperature fields. Longitudinal-transverse sweep method. Nonstationary boundary conditions

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 identified 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.

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 understanding 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

Sl.№	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	Henner V. Mathematical Methods in Physics. Partial Differential Equations, Fourier Series, and Special Functions / V. Henner, T. Belozerova, K. Forinash. - Wellesley. Massachusetts: A K Peters. Ltd, 2009.	1
2	Busch G. Lectures on Solid State Physics : Transl. from Germ. / G. Busch, H. Schade. - Oxford: Pergamon Press, 1976.	1
2. Additional literature		
2.1. Educational and scientific literature		
3	In the world of science = Scientific American: scientific-inform. journal / In the world of science. - M.: In the world of science. 2004-2009. - Monthly	
4	Skibicki W. Slownik Terminow Fizycznych. Glossary of Physics. Dictionnaire de Physique. Physikalisches Wörterbuch. Dictionary of Physics: Polsko-Angielsko-Francusko-Niemiecko-Rosyjski / W. Skibicki. - Warszawa: Panstwowe Wydawnictwo Naukowe, 1961.	1
5	Physics-Uspekhi (Advances in Physical Sciences) 1993-present Physics-Uspekhi Online ISSN: 1468-4780 Print ISSN: 1063-7869	
2.2. Standardized and Technical literature		
6	Sachs G. Practical Metallurgy. Applied Physical Metallurgy and the Industrial Processing of Ferrous and Nonferrous Metals and Alloys / G. Sachs, K. R. V. Horn. - Cleveland: American Society for Metals, 1940.	1
3. Students' manual in mastering discipline		
7	Fundamentals of Physics. Author, I.E. Irodov. Publisher, CBS Publishers & Distributors, 2005. ISBN, 8123903022, 9788123903026. Length, 455 pages.	
8	I.E Irodov's "Problems in General Physics" Arihant Publication; 6th edition (January 1, 2016)	
4. Teaching and learning materials for students' self-work		
9	Electronic library of the Scientific Library of Perm National Research Polytechnic University [Electronic resource]: [full-text database electron. documents published in the PNRPU Publishing House]. - Electron. Dan. (1912 entries) - Perm, 2014-2015. - Access mode: http://elib.pstu.ru/. - Title from the screen.	
10	American Physical Society Journals [Electronic resource]: [full-text database: electron. zhurn. in physics in English language] / American Physical Society (APS). - New York, 2015. - Available at: http://www.journals.aps.org. - Title from the screen.	

6.2. Electronic Courseware

Kind of literature	Name of training tool	Reference to information resource	Accessibility of EBN (Internet/local net; authorized free access)
Presentations	Physic's Lectures		authorized free access

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

Type of Software	Software branding

OS	Windows 10 (Azure Dev Tools for Teaching)
Office applications	Microsoft Office Professional 2007. lic. 42661567 Adobe Acrobat Reader DC
General-purpose application software	Dr. Web Enterprise Security Suite, 3000 license PNRPU OCNIT 2017
Image processing software	Corel CorelDRAW Suite X4
General purpose application software	Mathematical Professional Version (license L3263-7820*)
General purpose application software	Microsoft Office Visio Professional 2016 (Azure Dev Tools for Teaching)
General purpose application software	WinRAR (license №879261.1493674)
Management systems for projects, research, development, design, modeling and implementation	Autodesk AutoCAD 2019 Education Multi-seat Stand-alone

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

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

7. Logistics of the Course Educational Process

Type of classes	Name of the necessary basic equipment	Number of units
Laboratory class	Stand "Determination of the cylinder volume"	12
	Stand "Determination of free fall acceleration using the Atwood machine"	1
	Stand "Research of balls' collisions"	1
	Stand "Oberbek's Pendulum"	12
	Stand "Determination of the bullet's speed by the ballistic pendulum method"	1
	Stand "Study of the gyroscope precession"	1
	Stand "Maxwell's Pendulum"	1
	Stand "Physical pendulum"	10
	Stand "Determination of free fall acceleration by the method of revolving physical pendulum"	8
	Stand "Determination of the bodies inertia moment by the method of torsional vibrations"	2
	Stand "Study of free spring pendulum vibrations"	10
	Stand "Determination of the rolling friction coefficient by the inclined pendulum method"	1
	Stand "Determination of liquid viscosity by Stokes method"	10

	Stand "Determination of the adiabatic index for air"	4
	Stand "Measurement of the liquid viscosity coefficient and determination of the activation energy"	1
	Stand "Research of the surface tension water coefficient dependence on temperature"	1
	Stand "Measurement of the linear expansion temperature coefficient"	1
Laboratory class	Stand "Study of an electronic oscilloscope"	6
	Stand "Study of electrostatic fields"	10
	Stand "Determination of emf current source by the compensation method"	6
	Stand "Thermocouple calibration"	6
	Stand "Determination of magnetic induction in the device pole gap of the magnetoelectric system"	8
	Stand "Research of the circular current magnetic field"	4
	Stand "Determination of the Earth's magnetic field induction using a cathode-ray tube"	6
	Stand "Study of the electromagnetic induction and mutual induction phenomenon"	1
	Stand "Study of the electronic oscilloscope hysteresis phenomenon"	4
	Stand "Investigation of the magnets dynamic susceptibility"	1
	Stand "Study of damped oscillations in a circuit"	4
	Stand "Study of forced vibrations in a sequential circuit"	1
Laboratory class	Stand "Determination of the solids refractive index using a microscope"	6
	Stand "Determination of the lenses focal length"	6
	Stand "Determination of the Newton's lens curvature radius"	6
	Stand "Determination of the light wavelength using Newton's rings "	6
	Stand "Fresnel Biprism"	4
	Stand "Interference of laser light in a thick plate"	2
	Stand "Determination of the light wavelength using diffraction grating"	6
	Stand "Study of the light diffraction phenomenon by diffraction grating"	6
Laboratory class	Stand "Determining the distance between gaps in Jung's experiment"	6
	Stand "Diffraction by a slit, systems of slits, one-dimensional and two-dimensional diffraction gratings"	6
	Stand "Determination of the sugar solution concentration with a polarimeter"	2
	Stand "Determination of the laser beam polarization degree. Study of Malus' and Brewster's Laws"	6
	Stand "Receiving and studying elliptically polarized light"	6
	Stand "Measurement of the liquid refractive index using the Rayleigh interferometer"	1
	Stand "Determination of surface roughness using the Linnik microinterferometer"	1

	Stand "Measurement of the body temperature and integral emissivity by the spectral relations method"	6
	Stand "Study of the LED emission spectrum"	2
	Stand "Photocell research"	4
	Stand "External photo effect. Planck constant"	2
	Stand "Spectral characteristics of photoconductivity"	2
	Stand "Determination of the Stefan-Boltzmann constant using the disappearing filament pyrometer"	1
	Stand "Determination of the Planck constant using a LED"	4
	Stand "Investigation of line emission spectra using the UM-3 monochromator"	2
	Stand "Study of the substance light absorption dependence on the light wave length"	2
	Stand "Investigation of semiconductors electrical characteristics using the Hall effect"	1
	Stand "Study of semiconductors electrical resistance dependence on temperature"	1
	Stand "Study of the metals electrical resistance dependence on temperature"	1

8. Fund of the Course Evaluating Tools

Described in a separate document