Federal State Autonomous Educational Institution of Higher Education "Moscow Institute of Physics and Technology (National Research University)"

APPROVED
Vice Rector for Academic Affairs

A.A. Voronov

Work program of the course (training module)

course:	General Physics: Introduction to Physics/Общая физика: введение в физику
major:	Biotechnology
specialization:	Biomedical Engineering/Биомедицинская инженерия
	Phystech School of Biological and Medical Physics
	Chair of General Physics
term:	1
qualification:	Bachelor

Semester, form of interim assessment: 1 (fall) - Exam

Academic hours: 90 AH in total, including:
lectures: 60 AH.
seminars: 30 AH.
laboratory practical: 0 AH.

Independent work: 60 AH.

Exam preparation: 30 AH.

In total: 180 AH, credits in total: 4

Number of course papers, tasks: 2

Authors of the program:

P.V. Popov, candidate of physics and mathematical sciences
A.V. Ilin, candidate of physics and mathematical sciences, associate professor

The program was discussed at the Chair of General Physics 25.10.2022

Annotation

Mastering basic knowledge by students for further study of other branches of physics.

1. Study objective

Purpose of the course

Development of students ' basic knowledge of General physics for further study of other branches of physics.

Tasks of the course

- Formation of skills and abilities to apply the studied theoretical laws and mathematical tools to solve various physical problems
- formation of physical culture: the ability to distinguish the essential physical phenomena and to disregard the irrelevant; ability to conduct evaluations of physical quantities; ability to build a simple theoretical model is described serving the physical processesTasks of the Discipline.

2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program

Mastering the discipline is aimed at the formation of the following competencies:

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Apply knowledge of mathematical, physical, chemical, biological laws, patterns, and interrelation to study, analyze, and utilize biological objects and processes	Gen.Pro.C-1.1 Analyze the task in hand, outline the ways to complete it
Pro.C-1 Plan and conduct scientific experiments (in a selected subject area) and/or theoretical (analytical and simulation) research	Pro.C-1.1 Understand the fundamental concepts, laws, and theories of modern physics and biology

3. List of the planned results of the course (training module)

As a result of studying the course the student should:

know:

To know:

- to understand the essence of algorithmic requirements and the ability to act in accordance with the proposed algorithm;
- know the basic methods of experimental study of nature
- have an idea of the basic mathematical concepts (number, geometric figure, equation, function);
- have an idea of the basic physical concepts (material point, reference system, system of units).

be able to:

Be able to:

- be able to understand and use mathematical means of visualization (charts, diagrams, tables, diagrams, etc.);
- have the skills of oral, written, instrumental calculations;
- be able to use the simplest means of measurement.

master:

To be in command of:

- to master the techniques of performing identical transformations of rational expressions, solving equations, systems of equations, the ability to use the idea of coordinates on the plane for the interpretation of equations, inequalities, systems; the ability to apply algebraic transformations, apparatus of equations and inequalities for solving problems,
- to know the system of functional concepts, functional language and symbols; the ability to use functional and graphical representations for the description and analysis of real dependencies;
- possess the skills of geometric constructions, perform drawings, make drawings, diagrams on the condition of tasks.

4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions

4.1. The sections of the course (training module) and the complexity of the types of training sessions

№	Topic (section) of the course	Types of training sessions, including independent work			
		Lectures	Seminars	Laboratory practical	Independent work
1	Kinematics of uniform motion and accelerated motion.	4	2		4
2	Dynamics of point particle	4	2		4
3	System of bodies.	4	2		4
4	Work and energy.	4	2		4
5	Gravitation	4	2		4
6	Statics and dynamics of rigid bodies	4	2		4
7	Ideal gases.	4	2		4
8	Conservation of energy in various processes	4	2		4
9	Properties of liquids and vapors	4	2		4
10	Electrostatics.	4	2		4
11	Electric current	4	2		4
12	Magnetic field of a current.	4	2		4
13	Alternating current	4	2		4
14	Geometric optics	4	2		4
15	Physical optics	4	2		4
AH in total		60	30		60
Exam preparation		30 AH.			
Total complexity		180 AH., credits in total 4			

4.2. Content of the course (training module), structured by topics (sections)

Semester: 1 (Fall)

1. Kinematics of uniform motion and accelerated motion.

The subject and role of physics. Limits of applicability of physical laws. Measurement of physical quantities. Uniform rectilinear motion and curvilinear motion. Uniformly accelerated motion. Reference frames.

2. Dynamics of point particle

Forces in nature. Newton's laws and dynamics of rectilinear and curvilinear motion.

3. System of bodies.

Momentum of a body and impulse of force. Law of momentum conservation. Collisions.

4. Work and energy.

Work done by force. Potential energy and kinetic energy. The law of conservation of energy.

5. Gravitation

Law of universal gravitation. Orbital velocity and escape velocity. Geostationary earth orbit satellite.

6. Statics and dynamics of rigid bodies

Torque and general condition of equilibrium. Hydrostatics. Dynamics of rigid bodies.

7. Ideal gases.

Equation of state of an ideal gas. Dalton’s law and Avogadro’s law.

8. Conservation of energy in various processes

First law of thermodynamics. Adiabatic and isothermal processes.

9. Properties of liquids and vapors

Surface tension. Capillary phenomena. Mutual conversion of liquids, solids, and vapors.

10. Electrostatics.

Electric charges and electric fields. Capacitors. Potential difference. Energy of electric field.

11. Electric current

Ohm's Law. Resistivity. Series and parallel connection of resistors.

12. Magnetic field of a current.

Action of magnetic field on an electric current and moving charge. Electromagnetic induction.

13. Alternating current

Induced current. Faraday law. Transformers.

14. Geometric optics

Reflection and refraction of light. Thin lens equation and optical instruments.

15. Physical optics

Wave properties of light. Interference and diffraction of light. Diffraction grating. Dispersion of light and colors of bodies. Polarization of light.

5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)

Facilities and Resources:
- A lecture audience equipped with a multimedia projector and a screen.
- Equipment for lecture demonstrations.
- Classrooms equipped with a board.
- Libraries of educational and technical literature, including electronic libraries, necessary for individual work of students.

6. List of the main and additional literature, that is necessary for the course (training module) mastering

Main literature

1. Physics: A General Course v. 1: Mechanics, Molecular Physics (by I.V. Savelyev), Central Books Ltd (1981), Mir Publishers (1989)
2. General Physics: Mechanics and Molecular Physics (by L. Landau, A. Akhiezer, E. Lifshitz), Pergamon Press (1967)
3. Problems in General Physics (by I.E. Irodov), Mir Publishers (Revised edition 1988)

Additional literature

1. Fundamental Laws of Mechanics (by I.E. Irodov), Mir Publishers (Moscow), CBS Publishers & Distributors (India), 6th edition (2016)
2. Berkeley Physics Course: Vol. 1 - Mechanics (by C. Kittel, W.D. Knight, and M.A. Ruderman), McGraw-Hill, New York, second edition (1973)
3. The Feynman Lectures on Physics, The Definitive Edition Volume 1: (2nd Edition) by Richard P. Feynman and Robert B. Leighton, Addison Wesley; 2nd edition (2005)

7. List of web resources that are necessary for the course (training module) mastering

1. http://mipt.ru/education/chair/physics/S_IV/Metod_4/— методический раздел сайта кафедры Общей физики
2. http://lib.mipt.ru/catalogue/1412/?t=750 – электронная библиотека МФТИ, раздел «Общая физика»

8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)

The List of Informational Resources:

1. Methodical section of the Department of General Physics website: http://mipt.ru/education/chair/physics/S_I/method/.
2. MIPT electronic library, the General Physics section: http://lib.mipt.ru/catalogue/1412/?t=750.

Lecture halls are equipped with multimedia and presentation facilities.

The recommended literature is available in electronic form (see paragraphs [1, 2] of the list of Internet resources necessary for mastering the discipline modules) so that the students may read textbooks using their tablets.

9. Guidelines for students to master the course

Guidelines for Students on Mastering the Discipline:

A student studying the general physics course must learn the general physics laws and concepts, and how to apply them in practice.

Successful mastering of the course requires intensive individual work of each student. The course program informs of the minimum time required for the student to work on the course topics. The individual work includes:

- reading and making summary of recommended literature,
- studying educational materials (lecture notes, educational and scientific literature), preparing answers to questions intended for self-study;
- solving the problems offered to students in lectures and seminars,
- passing assignments and preparing for seminars, tests, and exams.

Guidance and control of individual work is offered to students in the form of individual consultations.

The ability to solve problems is an indicator of the student's mastery of physics. To develop such ability, a student needs to solve as many problems as possible. When solving a problem, a student must be able to explain each action on the basis of the studied theoretical topics and carry out all the necessary calculations to bring the solution to a final answer. A problem is considered solved if it contains substantiated actions including references to the applicable physical laws and correct calculations, as well as the correct numerical answer (if the problem contains numerical data).

When preparing for a seminar, students must learn the basic concepts and laws to which the seminar will be devoted, and solve the problems envisaged for preparation to the seminar topic.

Physics makes use of many concepts and methods of calculus. If a student encounters a mathematical concept that has not yet been studied in the framework of mathematical courses then he/she must learn the relevant section of math individually. The necessary minimum of mathematical information is presented both at lectures and in the recommended literature.

The mid-semester control of knowledge is conducted in the form of a written test, in which the student is offered to solve five problems on the studied topics. The written test is given in the format similar to a written exam. In order to test the student's level of knowledge and understanding of the material, the teacher may ask the student, during the presentation of the assignment, additional theoretical questions on the syllabus or give additional problems to solve. Each student is required to complete, in a special notebook, the homework assignments and submit them for inspection.

At the written exam, the student is asked to solve five problems. The subjects of the problems are fully consistent with the physics course syllabus. However, all the problems in the written exam are completely non-typical. At the exam, students are allowed to use a sheet of paper with formulas written on it in advance. Such form of exam eliminates mindless memorization of formulas and is aimed at checking the depth of understanding of the material and the ability to apply physical laws in an unusual situation.

Students are recommended to study individually various topics related to general physics, possibly beyond the scope of the program, thus expanding their physical horizon. At the exam, the student is offered to present any theoretical or experimental topic prepared in advance and related to the course of physics. This can be either an in-depth presentation of one of the syllabus topics or a topic not covered in the syllabus, which can, however, be considered as part of the physics course studied, thus demonstrating the ability to understand various issues and problems of physics based on the use of general physical laws.

SUPPLEMENT

Assessment funds for course (training module)

major:	Biotechnology
specialization:	Biomedical Engineering/Биомедицинская инженерия
	Phystech School of Biological and Medical Physics
	Chair of General Physics
term:	1
qualification:	Bachelor

Semester, form of interim assessment: 1 (fall) - Exam

Authors:

P.V. Popov, candidate of physics and mathematical sciences
A.V. Ilin, candidate of physics and mathematical sciences, associate professor

1. Competencies formed during the process of studying the course

Code and the name of the competence	Competency indicators
Gen.Pro.C-1 Apply knowledge of mathematical, physical, chemical, biological laws, patterns, and interrelation to study, analyze, and utilize biological objects and processes	Gen.Pro.C-1.1 Analyze the task in hand, outline the ways to complete it
Pro.C-1 Plan and conduct scientific experiments (in a selected subject area) and/or theoretical (analytical and simulation) research	Pro.C-1.1 Understand the fundamental concepts, laws, and theories of modern physics and biology

2. Competency assessment indicators

As a result of studying the course the student should:

know:

To know:

- to understand the essence of algorithmic requirements and the ability to act in accordance with the proposed algorithm;
- know the basic methods of experimental study of nature
- have an idea of the basic mathematical concepts (number, geometric figure, equation, function);
- have an idea of the basic physical concepts (material point, reference system, system of units).

be able to:

Be able to:

- be able to understand and use mathematical means of visualization (charts, diagrams, tables, diagrams, etc.);
- have the skills of oral, written, instrumental calculations;
- be able to use the simplest means of measurement.

master:

To be in command of:

- to master the techniques of performing identical transformations of rational expressions, solving equations, systems of equations, the ability to use the idea of coordinates on the plane for the interpretation of equations, inequalities, systems; the ability to apply algebraic transformations, apparatus of equations and inequalities for solving problems,
- to know the system of functional concepts, functional language and symbols; the ability to use functional and graphical representations for the description and analysis of real dependencies;
- possess the skills of geometric constructions, perform drawings, make drawings, diagrams on the condition of tasks.

3. List of typical control tasks used to evaluate knowledge and skills

The list of typical assignments used to assess the level of knowledge and skills of the students.

Intermediate certification of students in General Physics is carried out in the form of examination. The exam consists of two parts: a written test, and an oral exam.

At the written test a student is offered to solve five problems. Each problem is an original author's product especially prepared for the exam.

At the oral exam each student has to choose an exam card from a pile of exam cards. Each card contains a theoretical question from the below list of exam questions. In addition, the student is asked to present a “question of choice” prepared in advance, which may be either one of the items in the below list of questions, or any question that is addressed in the course being studied or directly related to it.

4. Evaluation criteria

Examples of Questions from the Exam Cards:

1) Dynamics of point particle: laws of Newtonian mechanics.

2) The law of conservation of momentum. Collisions of particles.
3) First law of thermodynamics. Adiabatic and isothermal processes.
4) Ohm's law for complete electrical circuit.
5) Sources of electrical current and voltage. Induced current. Faraday law. Transformers.
6) Geometric optics. Reflection and refraction of light. Thin lens equation.
7) Images of extended objects formed by spherical mirrors and lenses.

Examples of Oral Exam Additional Questions:

Below are examples of simple questions that a student may be asked to answer at the first semester oral exam to get a satisfactory mark (in order to get a mark higher than satisfactory, the student should be ready to answer more complicated questions):

• Find the speed of an arbitrary point of the rim of the wheel that is rolling on a plane without slipping.
• Find the height-angle relationship for a body thrown at an angle to the horizontal.
• Obtain the formula for the power of the force acting on a moving particle.
• Derive an expression for the potential energy of a spring that obeys the Hooke's law.
• What is the center of mass of a system of particles? Derive the formula for the coordinate of the center of mass.
• Obtain an expression for the potential energy of gravitational interaction of two point masses m at a distance r.
• Derive the formula for the first cosmic velocity (orbital velocity).
• Obtain the expression for the second cosmic velocity (escape velocity).
• The carousel rotates at an angular velocity ω. What inertial forces are acting on the moving body in the reference frame of the carousel?
• Explain the equation of state of an ideal gas.
• Draw graphs of different gas processes (isothermal, isobaric, etc.)
• Explain the Coulomb's law and superposition principle in electrostatics.
• What is the self-induction phenomenon in a wire coil?
• Explain the method of obtaining images using a thin lens.

The mark given for the written exam depends on the problem solutions presented by a student. Each problem solution is evaluated according to a three-point grading scale, i.e. each solution is assigned from 0 to 3 points according to the following criteria:

3 points: The problem is solved completely and correctly, i.e. the correct well-founded solution is given and all questions of the problem are answered. Minor flaws may be present (a slip of the pen, or insignificant arithmetic errors).

2 points: The problem is solved, the logic of solution as a whole is correct but there are significant shortcomings (errors in calculations, an absurd answer, etc.).

1 point: The problem is not solved, but all the basic physical laws necessary for the solution are formulated correctly.

0 points: The problem is not solved or solved incorrectly (the basic laws are written with errors, or not completely, the approach to solving the problem is fundamentally wrong, or the solution to the problem does not match the statement).

The points for the five problems of written exam are summed up, the mark and the final score for the written exam are set according to the following scheme:

The sum of all points	Score	Mark
15	10	Excellent
13-14	9	
12	8	
11	7	Good
9-10	6	
8	5	

6-7 4 Satisfactory
5 3
2-4 2 Unsatisfactory
0-1 1

The written exam score determines the maximum final score that a student may get at the oral exam. In exceptional cases, when the student demonstrates, during the oral exam, excellent theo-retical knowledge and superb level of understanding of the subject, the final score for the oral exam may be increased but no more than by two points (on a 10-point scale).

At the oral exam, the teacher will assess the student's answer as a whole and assign a mark ac-cording to the criteria set forth below and the above comments regarding the written exam score:

The mark "Excellent" (10 points) is given to a student who has shown comprehensive and sys-tematic knowledge of the syllabus and beyond, as well as the ability to confidently apply the knowledge in solving complicated non-standard problems.

The mark "Excellent" (9 points) is given to a student who has shown comprehensive and sys-tematic knowledge of the syllabus and the ability to confidently apply the knowledge in solving non-standard problems.

The mark "excellent" (8 points) is given to a student who has shown comprehensive and system-atic knowledge of the syllabus and the ability to confidently apply the knowledge in solving non-standard problems but who has allowed for some inaccuracies.

The mark "good" (7 points) is given to a student who has demonstrated firm knowledge and confident understanding of the syllabus and the ability to apply physical laws in solving typical problems.

The mark "good" (6 points) is given to a student who has demonstrated solid knowledge of the syllabus and the ability to apply physical laws in solving typical problems.

The mark "good" (5 points) is given to a student who has demonstrated firm knowledge and un-derstanding of the syllabus and the ability to apply physical laws in solving typical problems, however, made a number of gross inaccuracies when answering.

The mark "satisfactorily" (4 points) is given to a student who has shown a fragmentary knowledge and made mistakes in formulation of basic laws and concepts, but at the same time demonstrated the ability to solve simple problems and understanding of the main sections of syl-labus necessary for further education.

The mark "satisfactorily" (3 points) is given to a student who has shown a highly fragmented knowledge, made gross mistakes in the formulation of basic laws and concepts, but at the same time demonstrated the ability to solve simple problems and understand the main sections of syl-labus required for further education.

The mark "unsatisfactory" (2 points) or "unsatisfactory" (1 point) is given to a student who knows little of the main content of syllabus, systematically makes gross mistakes in formulating basic physical laws, or is unable to correctly apply physical laws even to solve simple problems.

5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience

The Procedure for Written Exam

The duration of the written exam is four astronomical hours. The exam offers to solve five original problems, which correspond to the topics studied at seminars during the semester. A problem is considered solved if it contains a well-founded solution that includes references to the applied physical laws and correct calculations, as well as the correct numerical answer (if the problem contains numerical data). A student can use at the exam a sheet of paper with formulas prepared in advance. It is strictly forbidden to use any notebooks, or compendiums of lectures, or textbooks, or devices that can serve as means of communication, like laptops, tablets, phones, etc. Violators are removed from the exam with the "unsatisfactory" mark. It is allowed to use calcula-tors with no communication facilities. It is forbidden to use calculators in mobile phones, laptops, etc.

The Procedure for Oral Exam

The oral exam is held in traditional form of teacher's conversation with a student on the topic contained in the examination card. The exam card contains two items: a "question of choice" and a question from the course syllabus.

The question of choice may be selected and prepared by the student well before the exam. The student may ask the physics teacher for advice on the topic for the question of choice. A question of choice may be (1) an in-depth presentation of one of the syllabus topics, (2) a ques-tion or problem directly related to one of the topics of the physics course but not covered in it. Preparation for the question of choice at the oral exam should take no more than five minutes. The student is given 10 minutes to present his/her question of choice at the oral exam.

While presenting the question of choice, the student is allowed to use a plan of presentation and pre-prepared illustrations or graphs presented either on paper or electronic media like a tablet or laptop. Such graphics or illustrations may not contain any text of the report.

The student is given from 30 to 45 minutes to prepare the answer on the topic given in the exam card. During the exam, the student is not allowed to use any literature, computers, pre-prepared own records, or other materials related to the subject, except for the examination pro-gram of the course.

In discussing the exam card topic, the examiner may ask clarifying questions. Also, the ex-aminer has the right to ask the student any additional questions on the syllabus.

In the aggregate, the duration of oral exam for one student should not exceed two astro-nomical hours.

3. The list of typical assignments used to assess the level of knowledge and skills of the students.

Intermediate certification of students in *General Physics* is carried out in the form of examination. The exam consists of two parts: a written test, and an oral exam.

At the written test a student is offered to solve five problems. Each problem is an original author's product especially prepared for the exam.

At the oral exam each student has to choose an exam card from a pile of exam cards. Each card contains a theoretical question from the below list of exam questions. In addition, the student is asked to present a "question of choice" prepared in advance, which may be either one of the items in the below list of questions, or any question that is addressed in the course being studied or directly related to it.

Examples of Questions from the Exam Cards:

1) Dynamics of point particle: laws of Newtonian mechanics.
2) The law of conservation of momentum. Collisions of particles.
3) First law of thermodynamics. Adiabatic and isothermal processes.
4) Ohm's law for complete electrical circuit.
5) Sources of electrical current and voltage. Induced current. Faraday law. Transformers.
6) Geometric optics. Reflection and refraction of light. Thin lens equation.
7) Images of extended objects formed by spherical mirrors and lenses.

Examples of Oral Exam Additional Questions:

Below are examples of simple questions that a student may be asked to answer at the first semester oral exam to get a satisfactory mark (in order to get a mark higher than satisfactory, the student should be ready to answer more complicated questions):

- Find the speed of an arbitrary point of the rim of the wheel that is rolling on a plane without slipping.
- Find the height-angle relationship for a body thrown at an angle to the horizontal.
- Obtain the formula for the power of the force acting on a moving particle.
- Derive an expression for the potential energy of a spring that obeys the Hooke's law.
- What is the center of mass of a system of particles? Derive the formula for the coordinate of the center of mass.
- Obtain an expression for the potential energy of gravitational interaction of two point masses m at a distance r.
- Derive the formula for the first cosmic velocity (orbital velocity).
- Obtain the expression for the second cosmic velocity (escape velocity).
- The carousel rotates at an angular velocity ω. What inertial forces are acting on the moving body in the reference frame of the carousel?
- Explain the equation of state of an ideal gas.
- Draw graphs of different gas processes (isothermal, isobaric, etc.)
- Explain the Coulomb's law and superposition principle in electrostatics.
- What is the self-induction phenomenon in a wire coil?
- Explain the method of obtaining images using a thin lens.

4. Evaluation Criteria

The mark given for the written exam depends on the problem solutions presented by a student. Each problem solution is evaluated according to a three-point grading scale, i.e. each solution is assigned from 0 to 3 points according to the following criteria:

3 points: The problem is solved completely and correctly, i.e. the correct well-founded solution is given and all questions of the problem are answered. Minor flaws may be present (a slip of the pen, or insignificant arithmetic errors).

2 points: The problem is solved, the logic of solution as a whole is correct but there are significant shortcomings (errors in calculations, an absurd answer, etc.).

1 point: The problem is not solved, but all the basic physical laws necessary for the solution are formulated correctly.

0 points: The problem is not solved or solved incorrectly (the basic laws are written with errors, or not completely, the approach to solving the problem is fundamentally wrong, or the solution to the problem does not match the statement).

The points for the five problems of written exam are summed up, the mark and the final score for the written exam are set according to the following scheme:

The sum of all points	**Score**	**Mark**
15	10	Excellent
13-14	9	
12	8	
11	7	Good
9-10	6	
8	5	
6-7	4	Satisfactory
5	3	
2-4	2	Unsatisfactory
0-1	1	

The written exam score determines the maximum final score that a student may get at the oral exam. In exceptional cases, when the student demonstrates, during the oral exam, excellent theoretical knowledge and superb level of understanding of the subject, the final score for the oral exam may be increased but no more than by two points (on a 10-point scale).

At the oral exam, the teacher will assess the student's answer as a whole and assign a mark according to the criteria set forth below and the above comments regarding the written exam score:

The mark **"Excellent"** (10 points) is given to a student who has shown comprehensive and systematic knowledge of the syllabus and beyond, as well as the ability to confidently apply the knowledge in solving complicated non-standard problems.

The mark **"Excellent"** (9 points) is given to a student who has shown comprehensive and systematic knowledge of the syllabus and the ability to confidently apply the knowledge in solving non-standard problems.

The mark **"excellent"** (8 points) is given to a student who has shown comprehensive and systematic knowledge of the syllabus and the ability to confidently apply the knowledge in solving non-standard problems but who has allowed for some inaccuracies.

The mark **"good"** (7 points) is given to a student who has demonstrated firm knowledge and confident understanding of the syllabus and the ability to apply physical laws in solving typical problems.

The mark **"good"** (6 points) is given to a student who has demonstrated solid knowledge of the syllabus and the ability to apply physical laws in solving typical problems.

The mark **"good"** (5 points) is given to a student who has demonstrated firm knowledge and understanding of the syllabus and the ability to apply physical laws in solving typical problems, however, made a number of gross inaccuracies when answering.

The mark **"satisfactorily"** (4 points) is given to a student who has shown a fragmentary knowledge and made mistakes in formulation of basic laws and concepts, but at the same time demonstrated the ability to solve simple problems and understanding of the main sections of syllabus necessary for further education.

The mark **"satisfactorily"** (3 points) is given to a student who has shown a highly fragmented knowledge, made gross mistakes in the formulation of basic laws and concepts, but at the same time demonstrated the ability to solve simple problems and understand the main sections of syllabus required for further education.

The mark **"unsatisfactory"** (2 points) or **"unsatisfactory"** (1 point) is given to a student who knows little of the main content of syllabus, systematically makes gross mistakes in formulating basic physical laws, or is unable to correctly apply physical laws even to solve simple problems.

5. Teaching Aids Defining the Procedures for Assessing Knowledge, Skills, Abilities and/or Experience

The Procedure for Written Exam

The duration of the written exam is four astronomical hours. The exam offers to solve five original problems, which correspond to the topics studied at seminars during the semester. A problem is considered solved if it contains a well-founded solution that includes references to the applied physical laws and correct calculations, as well as the correct numerical answer (if the problem contains numerical data). A student can use at the exam a sheet of paper with formulas prepared in advance. It is strictly forbidden to use any notebooks, or compendiums of lectures, or textbooks, or devices that can serve as means of communication, like laptops, tablets, phones, etc. Violators are removed from the exam with the "unsatisfactory" mark. It is allowed to use calculators with no communication facilities. It is forbidden to use calculators in mobile phones, laptops, etc.

The Procedure for Oral Exam

The oral exam is held in traditional form of teacher's conversation with a student on the topic contained in the examination card. The exam card contains two items: a "question of choice" and a question from the course syllabus.

The question of choice may be selected and prepared by the student well before the exam. The student may ask the physics teacher for advice on the topic for the question of choice. A question of choice may be (1) an in-depth presentation of one of the syllabus topics, (2) a question or problem directly related to one of the topics of the physics course but not covered in it. Preparation for the question of choice at the oral exam should take no more than five minutes. The student is given 10 minutes to present his/her question of choice at the oral exam.

While presenting the question of choice, the student is allowed to use a plan of presentation and pre-prepared illustrations or graphs presented either on paper or electronic media like a tablet or laptop. Such graphics or illustrations may not contain any text of the report.

The student is given from 30 to 45 minutes to prepare the answer on the topic given in the exam card. During the exam, the student is not allowed to use any literature, computers, pre-prepared own records, or other materials related to the subject, except for the examination program of the course.

In discussing the exam card topic, the examiner may ask clarifying questions. Also, the examiner has the right to ask the student any additional questions on the syllabus.

In the aggregate, the duration of oral exam for one student should not exceed two astronomical hours.