Basic Physics Laboratory

Tutor Guide

Academic Year 2019–2020

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РФ
НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ ТОМСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
САЕ ИНСТИТУТ «УМНЫЕ МАТЕРИАЛЫ И ТЕХНОЛОГИИ»

BASIC PHYSICS LABORATORY
TUTOR GUIDE
ОСНОВЫ ЭКСПЕРИМЕНТАЛЬНОЙ ФИЗИКИ

Методическое руководство по курсу «Основы экспериментальной физики» для преподавателей автономной образовательной программы бакалавриата «Tomsk International Science Program» направления подготовки 27.03.05 - Инноватика

Томск 2020

РАССМОТРЕНО И УТВЕРЖДЕНО методической комиссией САЕ Институт «Умные материалы и технологии»
Протокол № 1 от «7» сентября 2020 г.
Председатель МК И.А. Курзина

Методическое руководство составлено в соответствии с тематикой практических занятий курса «Элементы физики» и программой курса «Основы экспериментальной физики» для преподавателей автономной образовательной программы бакалавриата «Tomsk International Science Program» (TISP) направления подготовки 27.03.05 Инноватика. Методическое руководство содержит программы и темы лабораторных занятий, методические указания к их проведению с использованием рейтингового контроля и оцениванию.
Для преподавателей программы TISP.

СОСТАВИТЕЛИ: М.О. Плешков, В.Ф. Нявро, Д.Н. Старков, Д.А. Безродный

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1. INTRODUCTION

Title: Basic physics laboratory
Number of ECTS: 2

Amount of contact hours	72
Including:	
Practical training	0
Lectures	0
Laboratory works	32
Consultations during study	1.85
Student's self-study	38.15
Consultation before the credit test	
Self-study before credit test	
Graded credit test (per student)	

1. Aims of the course
Mastering by students the methods of planning, performing a physical experiment and presenting a written report on the work performed.

2. Place of the discipline within the curriculum
Discipline belongs to the core of the program, it has no prerequisites. The discipline "Basic Physics Laboratory" is conducted in conjunction with the discipline "Elements of Physics" and supplements it. The post-requisites are the disciplines "Classical Mechanics" and "Physical Laboratory: Classical Mechanics".

3. Competences after completion of this course
• **ОПК-7** – To be able to apply knowledge of mathematics, physics and natural science, chemistry and materials science, control theory and information technology in innovation.
Learning results Student will be able to: – solve technical problems in physical experiment based on the understanding of the practical approaches in experimental physics; – relate an experiment with physics theory.
• **ПК-8** – To be able to apply convergent and multidisciplinary knowledge, modern research **methods** and project modeling using computer technology and appropriate software systems.

Learning results Student will be able to: – apply the basic methods of statistical data analysis; – use Microsoft Excel software to calculate the confidence intervals and construct basic regression models.
• **ПК-10** – able to plan the necessary experiment, get an adequate model and investigate it.
Learning results Student will be able to: – process the empirical data using statistical and graphical tools; – correctly describe the experimental methods and results in the frames of technical report; – work in team using communication skills such as responsible and ethical behavior.
• **ПК-11** – able to prepare presentations, scientific and technical reports on the results of the work performed, to draw up research results in the form of articles and reports.
Learning results Student will be able to: – present scientific information on the results of the physics experiment in written.

4. Literature, references
There is no book directly associated to this course. Information on the individual experiments is provided in this syllabus and in separate detailed experiment descriptions (lab manuals). Additionally, this course relates to the introductory course “Elements of Physics”. The textbooks for this course are: • I.V. Savelyev. Physics a general course. Volume I Mechanics Molecular Physics. Mir Publishers (1989); • I.V. Savelyev. Physics a general course. Volume II Electricity and Magnetism Waves Optics. Mir Publishers (1989); • I.V. Savelyev. Physics a general course. Volume III Quantum optics, atomic physics solid state physics physics of the atomic nucleus and elementary particles. Mir Publishers (1989); • David Halliday, Robert Resnick, Jearl Walker. Fundamentals of Physics. Wiley; 10 edition (2013). For the underlying physical principles of the experiments we refer to these textbooks.
Databases, information systems: None.
Licensed software Microsoft Excel.

5. Facilities and equipment
This course takes place in the physics laboratories of TSU Physics Faculty (2nd building rooms # 243, 230, 307). Equipment: PC, blackboard and chalk. The list of equipment for each of the laboratory works will be given un the section 7. (https://drive.google.com/drive/u/0/folders/1FVTqzKfDSSrWcxU9EI5_h94LYahcFNY7).

2. GENERAL INFORMATION FOR A TUTOR

The goal of this course is for participants to understand what physics means by performing instructive physics experiments that reveal fundamental physical principles, and to achieve a level of dexterity with experimental devices. Physics is an experimental science, not just a set of mathematical laws. In this sense, this practice is a suitable counterpart for more theoretical and mathematical physics courses.

The course consists of 8 labs designed to improve the ability to communicate and summarize experimental work across multiple pages.

Students work in pairs and conduct different experiments each week. Each week requires participants to study theory, design and plan an appropriate experiment, collect and analyze their data in order to understand the physical principles contained in it.

Duties of the teacher in relation to the organization of the educational process in the discipline:

- Track attendance at each session. Students must attend at least 85 % of classes (minimum 7 out of 8). If the student is unable to attend the class, he must inform the teacher and the course coordinator in advance by e-mail. If the student has not notified in advance, discuss it with him in the next session. Ask what he did to keep up with the group and explain that this behavior is unprofessional. A student who misses a lesson without a good reason must complete the lab in the next lesson. A student who has attended less than 7 classes without a valid excuse is not admitted to credit.
- Use the Class Assessment Techniques (CATs https://drive.google.com/drive/u/0/folders/1LBS4Bfg9hQsEp6stTtYbEmHvYLfIhwpJ) before the first lesson to determine the students' knowledge of the subject. You can use these techniques throughout the course to make sure you are on time. This type of control cannot affect the final grade for the course.
- If you have any problems during the course, or need additional material (eg CATs) contact the course coordinator.

3. STRUCTURE OF LABORATORY WORKS

Laboratory work involves work in small groups – no more than 15 students. In the lesson, students are divided into pairs (in the case of an odd number of students, it is allowed as work one or three).

During laboratory work, a tutor acts as an expert and a "scientific adviser" and often asks questions for reflection rather than giving mini-lectures on the topic of the lesson.

Tasks of the teacher:

- Create a favorable climate for students to work during classes;
- Clarify learning goals, help set the goal of the lesson;
- Help students plan and develop learning strategies;
- Engage in active learning, make sure that students keep up with the curriculum;
- Evaluate learning outcomes, including the results of the current control of knowledge (including through a checkpoint) and the final control of knowledge in the discipline.

Discipline implementation technology:

The Fundamentals of Experimental Physics course is based on a Problem-Based Learning (PBL) course and consists of four main parts. 1) Each pair of students receives their experiment (in order to avoid the intersection of two pairs of students or more behind the experimental setup) and a guide to its implementation; before each lesson, students study the obtained material. 2) At the beginning of the lesson, students first discuss the material with a tutor before getting admission to work with experimental equipment.

3) Directly performing the experiment. 4) Writing and evaluating the progress report. At the end of each lesson, students receive a new experiment, which they prepare for the next lesson, etc.

Recommendations for writing a report: students receive a file with the rules for preparing the report (see Appendix I), the basis for formatting the report is the structure of the scientific article. Reports are carried out in Microsoft Word or Latex, uploaded to the corresponding section of the assignment in the electronic platform Moodle / Google Classroom, and also sent to two students for peer-review.

4. CONTINUOUS ASSESSMENT AND THE CREDIT TEST

The credit for the discipline is set on the basis of summing up the actual points of the current control received by the student, provided that all control elements are completed.

Control element	Amount of elements	Points per element (max)	Total points
Instructor grading reports	8	5	40
Assessment of reports by students from each other. (Peer-review)	8	5	40
Assessment of answers to additional questions by the teacher	8	4	32
Availability of syllabus for laboratory work	8	3	24
Attendance at classes	8	2	16
Other (activity during the class)	8	1	8
		Credit test	0
		Total	160
Pass/Fail criterion			
< 140			Fail
140–160			Pass

The deadline for submitting completed reports on laboratory work to the teacher: Tuesday of the next week (until 23:59).

Deadline for submission of completed laboratory reports to each other (peer-review): Saturday next week (until 23:59).

The term for providing feedback to the tutor on the completed assignment (peer-review): Monday of the next week (until 23:59).

Evaluation criteria for monitoring elements

Current control is carried out on the basis of students' reports on laboratory work performed.

The evaluation criteria and the formatting guidelines for the reports are presented in Appendix I of Course Book.

A bank of questions and answers for monitoring laboratory work is presented at the end of each methodological manual.

The checkpoint is carried out on the 4th week of the course. A student receives a certified grade if, at the time of the checkpoint, he has 3 completed laboratory works, namely 3 evaluated reports for an assessment of at least 50 points.

Credit test

The credit consists of the work of students during classes, as well as the assessment of reports by the teacher and other students in accordance with clause 4.

5. PENALTY POINTS

Control element	Amount of elements	Points per element (max)	Total points
Being late up to 30 min	8	-1	-8
Skipped class	8	-2	-16

For each missed lesson, the student must submit the theoretical basis for the missed experiment and submit the report no later than the 7th week of the course. Upon successful delivery of the theoretical material, the student will receive +1 point to the assessment of the report.

6. FIRST CLASS

Lesson plan

- Acquaintance.
- Explanation of the rules for attending classes and passing the test with the assessment / exam.
- Incoming inspection using CATs assessment techniques.
- Discussion of the theory of the first experiment, execution of the experiment.

Acquaintance

Note student visits.

Let the students introduce themselves, introduce yourself.

Determine the expectations of the students / group from this course: explain to the students that you expect that this group of students will regularly attend classes (excluding missing for good reason), that an active participation of each student in the discussion is required if the student does not behave professionally (for example, without a valid reason / does not take an active part in the discussion), you will not notice his presence in the lesson. Explain to the students the concept of a "supportive learning environment" (do not interrupt, respect the opinions of classmates, consultations)

Explanation of the rules

Discuss with students the need for:

– professional behavior: come to classes on time, actively participate, if there is no opportunity to be at a laboratory lesson, inform the teacher and/or course coordinator in advance;

– using the already existing knowledge and experience without using records and computers when posing a problem;

– using a board for notes, diagrams, sketches;

– prepare schemes, diagrams for discussion in advance;
– current control and intermediate certification.

Incoming control

Describe the incoming control procedure, examples of questions. Entrance control should be organized in such a way as to allow a quick assessment of the knowledge and skills of students, for example, using the training platform, Kahoot.

Follow the link https://kahoot.com/ and sign in.

Go to the "My Kahoot" tab, select "discipline name" and click "Play".

Select "Classic" mode. The game PIN will appear.

Students must join https://kahoot.it/ on their smartphone or laptop and enter the game PIN and nickname.

When all student names appear on the screen, press Start.

The first question will appear, students have 20 seconds to answer it.

The correct answer is shown along with the names of the correct students.

Click Next to move on to the next question and repeat the same procedure until all questions are answered.

7. LABORATORY WORKS/EXPERIMENTS

Below are the titles of the works and their purpose. A more detailed description of each work is given in Course Book.

Experiment 1: Determining the acceleration of the gravity by the Bessel's pendulum

Purpose of the work: measuring the acceleration of gravity using the Bessel pendulum (mathematical pendulum).

Technical equipment

The Bessel pendulum is structured as follows: a heavy metal ball is attached to the lower end of a long string. The thread is located along the vertical bar, on which short rods are fixed at a distance of 50 cm from each other.

Experiment 2: Studying the basic law of translative motion dynamics

Purpose of work: calculation of acceleration and sliding friction coefficient when the body moves along an inclined plane.

Technical equipment

The installation for studying the movement of a bar along an inclined plane is an inclined plane that can be set with a screw at different angles to the horizon. The angle is measured using a scale. A bar can be placed on the plane. An electromagnet is used to hold the bar. The distance traveled by the bar can be measured with a ruler. A load is suspended on a thread thrown over the block.

Experiment 3: Measuring the viscosity coefficient of a liquid by the stokes method

Purpose of work: to get acquainted with some properties of liquids, with one of the methods for determining the viscosity coefficient of liquids and measuring the viscosity coefficient of castor oil or glycerin

Technical equipment

To carry out the work, a glass cylindrical vessel filled with the investigated viscous liquid is used. There are two marks on the walls of the vessel at a distance from each other. The upper mark should be 3 - 4 cm below the liquid level in order for the ball speed to be established by the time the upper mark passes.

The work uses small metal balls, the diameter of which is measured using a measuring microscope MIR-1.

Experiment 4: Measuring small resistance

Purpose of work: study of Ohm's law for direct current; construction of current-voltage characteristics of metal rods (copper and aluminum) and calculation of their resistivity.

Technical equipment

The experimental setup consists of: 1 – power supply (0…12 V/0…2 A); 2 – universal measuring amplifier: 3 – digital multimeter; 4 – conductive rods; 5 – connecting wires.

Experiment 5: Determining the specific charge of an electron by the method of longitudinal focus

Purpose of the work: to observe the phenomenon of electron focusing in a longitudinal magnetic field and to determine the charge-to-mass ratio for an electron.

Technical equipment

The focusing of electrons is observed in a cathode-ray tube of an oscilloscope with electrostatic deflection of particle beams. The cathode-ray tube is removed from the oscilloscope and placed inside a solenoid that creates a magnetic field directed along its axis.

Experiment 6: Determining the Wavelength of Light Using the Fresnel Biprism

Purpose of the work: studying the phenomenon of interference of light waves and determining the length of a light wave using a Fresnel biprism

Technical equipment

1. Laser Not-Ne; 2. Fresnel biprism on a table with a biprism holder; 3. Lens collecting L 1, with a holder for the lens; 4. Lens collecting L2, with a holder for the lens; 5. Optical bench 1000 mm long.

A tape measure is used to measure the distance to the screen. The screen is installed at a distance of more than 3 m. All devices are mounted on one optical axis.

Experiment 7: Determining the half-life period of a long-living isotope

Purpose of work: to get acquainted with the phenomenon of radioactivity. Experimentally determine the half-life of a natural radioactive isotope of potassium with a mass number of 40.

Technical equipment

The main part of the installation is the end counter

Experiment 8: Determining the Rydberg's constant

Purpose of work: studying the theory of the hydrogen atom according to Bohr. Calibration of the installation according to the known spectrum of mercury. Determination of energy levels of hydrogen and Rydberg constant.

Technical equipment

Gas discharge lamp filled with hydrogen; gas discharge lamp filled with mercury; high voltage power supply; diffraction grating; ruler.

Издание подготовлено в авторской редакции

Подписано в печать 24.11.2020 г.

Отпечатано на участке цифровой печати
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Заказ № 4491 от «24» ноября 2020 г. Тираж 50 экз.