National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

Department of Space Engineering

METROLOGY AND STANDARDIZATION

The working program of the study discipline (Syllabus)

Requisites of the Course	
Level of higher education	***Space Engineering***
Branch of knowledge	*134 - Aviation and rocket and space technology*
Specialty	*Aviation and rocket and space technology*
Educational program	*Space Engineering*
Discipline status	*Normative*
Form of education	*Full-time*
Year of training, semester	*3rd year, fall semester*
Scope of the discipline	*4 ECTS credits/120 hours, 36 hours lectures, 18 hours laboratory work*
Semester control/ control activities	*Exam*
Class schedule	*In accordance with the class schedule posted on the website http://rozklad.kpi.ua/*
Language of teaching	*English*
Information about head of the course / teachers	*Lecturers: prof. Korobko Ivan Vasyliovych korobko.kpi@gmail.com; Ph.D., associate professor Grishanova Iryna Arkadiivna, irgryshanova@gmail.com Laboratory: prof. Korobko Ivan Vasyliovych korobko.kpi@gmail.com; Assistant Viktoriya Vitalyivna Pavlova, xrumvik@gmail.com*
Link to course	https://classroom.google.com/c/NjI1NzE5NDkyODQz?cjc=ztrzplx

Outline of the Course

Course description, goals, objectives, and learning outcomes

The purpose of the discipline is to prepare students to solve organizational, scientific and technical problems of metrology and standardization in the design, production and operation of various measuring devices in the field of space engineering.

Competencies that the student will acquire during the study of the discipline

The ability to practically solve issues related to the metrological support of computer engineering systems and processes.

Ability to apply knowledge in practical situations.

Skills of performing safe activities.

The ability to design measuring instruments for space engineering, taking into account the requirements of relevant regulatory documents and international standards.

Program learning outcomes

To be able to apply knowledge about the basic principles and methods of measuring physical quantities and basic technological parameters to justify the choice of measuring instruments and evaluation of their metrological characteristics.

To be able to carry out an examination and implement measuring tools of various purposes used in space engineering, make changes and proposals in design and technological documentation in order to improve the quality of products

1. **Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)**

The study of the discipline is based on the knowledge and skills acquired during the study of "Physics", "Higher Mathematics", "Materials Science", etc.

In order to successfully study the discipline, students of higher education must possess the skills of using information technologies, the ability to search, process and analyze information from various sources.

The knowledge, skills and abilities acquired during the study of this discipline can be used during the study of the following disciplines: "Flight tests", "Theory of automatic control", etc.

1. Content of the academic discipline

Chapter 1. Basics of metrology and standardization.
Topic 1. Subject and tasks of metrology.
Topic 2. Measured quantities, their values and units.
Topic 3. The Unified International System of Measurement Units (ISU).
Topic 4. Theory of measurements.
Topic 5. Measuring equipment.
Topic 6. Subject and tasks of standardization.

Chapter 2. Measurement errors.
Topic 7. Errors of measurement tools.
Topic 8. Errors of measuring mechanisms.
Topic 9. Methods of error reduction..

Section 3. Processing of measurement results.
Topic 10. General issues of processing measurement results.
Topic 11. Methods of processing measurement results.

Chapter 4. Ensuring the unity of measurements.
Topic 12. Metrological certification of measuring devices.
Topic 13. Metrological support of production.

1. Educational materials and resources

Basic

1. Metrology and measuring technology: a textbook / E. S. Polishchuk, M. M. Dorozhovets, V. O. Yatsuk and others. ; under the editorship E. S. Polishchuk; Ministry of Education and Science, Youth and Sports of Ukraine, National Lviv Polytechnic University. – 2nd ed., supplement. and processing – Lviv: View of Lviv. polytechnics, 2012. – 544 p.
2. Bychkivskyi R.V. etc. Metrology, standardization, quality control and certification. - Lviv: Publishing House of the National University "Lviv Polytechnic", 2002. - 560 p.
3. Tsydelko V. D., Yaremchuk N. A., Zatoka S. A., Burchenkov G. K., Shvedova V. V., Stasevich V. A. Fundamentals of metrology and measuring technology: in 2 volumes: academic. manual / V. D. Tsydelko, N. A. Yaremchuk, S. A. Zatoka, etc. — K.: NTUU "KPI", 2013. — 1 vol. — 236 p.
4. Volodarskyi E.T., Kuharchuk V.V., Podzharenko V.O., Serdyuk G.B. Metrological support of measurements and control. Tutorial. – Vinnytsia: Veles, 2001. – 219 p.
5. Dorozhovets M. and others. Fundamentals of metrology and measuring technology: In 2 volumes / M. Dorozhovets, V. Motalo, B. Stadnyk, V. Vasylyuk, R. Borek, A. Kovalchyk; Edited by B. Stadnyka. — Lviv: Publishing House of the National University "Lviv Polytechnic", 2005. — Vol. 1. Fundamentals of metrology. — 532 p. .

Additional

6. World history of metrology: from ancient times to the end of the 19th century / Velichko O. M. — K.: Osnova, 2006. — 422 p.
7. Tsyutsyura S. V., Tsyutsyura V. D. Metrology, basics of measurements, standardization and certification: Education. manual — 3rd ed., pp. — K.: Znannia, 2006. — 241 p.
8. Certification tests and metrological support: training. manual [for students special "Quality, standardization and certification", "Metro. supply testing and product quality"] / O. P. Chaban; Ministry

of Education and Science of Ukraine, National Lviv Polytechnic University. – Lviv: View of Lviv. polytechnics, 2013. – 330, [2] p.
9. DSTU 2681-94 State Standard of Ukraine. Metrology. Terms and definitions.

Educational content

1. Methods of mastering an educational discipline (educational component)

Lectures

Section 1. Fundamentals of metrology and standardization.

Topic 1. Subject and tasks of metrology.
Topic 2. Measured quantities, their values and units.
Lecture 1. Metrology is the science of measurement. Physical quantities.
The focus of metrology. Metrology in the structure of science and production. The main tasks and problems of metrology.
Concept and classification of physical quantities. Basic quantities and units of measurement. Dimensionality of physical quantities, dimensional equations.

Topic 3. The Unified International System of Measurement Units.
Lecture 2. The Unified International System of Measurement Units.
Its meaning. The main values and units of it, their definitions. Rules for setting derived units. Multiples and fractional units.

Topic 4. Theory of measurements.
Lecture 3. Measurement.
Conditions and postulates of measurements. Types of measurements. Theoretical premises for the formation of various measurement theories (fundamental, physical, applied, logico-mathematical).
Lecture 4. General measurement methods.
Principles of obtaining measurement information. Classification of measurement methods. Method of direct measurements. Comparison method. Differential method.

Topic 5. Measuring equipment.
Lecture 5. Basic characteristics of measuring devices.
Types of measuring devices. Classification of measuring instruments. Structural schemes. Primary converters. Static, dynamic and metrological characteristics.

Topic 6. Subject and tasks of standardization.
Lecture 6. Subject and tasks of standardization.
Goals and objectives of standardization. Basic terms, definitions and concepts of standardization. Principles of standardization. Methods of standardization. Types and categories of standards.

Section 2. Measurement errors.

Topic 7. Errors of measurement tools.
Lecture 7. Measurement errors.
Types of errors. Classification of errors. Causes of errors. Static, dynamic and statistical errors. Accuracy classes of measuring instruments.
Lecture 8. Error calculation methods.
Error calculation methods: differential, probabilistic, geometric, transformed mechanism, plan of small movements.
Lecture 9. Evaluation of errors of measurement tools.
Estimation of permissible error values of input parameters based on the given error of the output parameter. Coefficients of influence of primary errors. The total error of the functional converter. Total error of the measuring device. Marginal errors.

Topic 8. Errors of measuring mechanisms.
Lecture 10. Errors of measuring mechanisms.

Typical functional schemes of measuring mechanisms and their kinematic pairs. Errors due to clearances, profile deviations of contacting surfaces. Errors due to dead movement of mechanisms. Error estimation according to the structural diagram.
Topic 9. Methods of error reduction.
Lecture 11. General methods of error reduction.
Application of compensators. Features of the selection of elements for the measuring circuit. Application of correlators. Automatic correction of additive and multiplicative errors.

Section 3. Processing of measurement results.
Topic 10. General issues of processing measurement results.
Lecture 12. Point assessment. Interval assessment.
Topic 11. Methods of processing measurement results.
Lecture 13. Detection of mistakes and gross errors. Modeling the dependence of measurement results. The method of least squares. Correlation method.
Lecture 14. Processing of direct, indirect, aggregate and compatible measurements.
Determination of the law of distribution of measurement results.
Lecture 15. Evaluation of systematic and random errors.
Assessment of reliability of measurement results. Determination of the number of measurements to ensure the given reliability of the assessment.

Chapter 4. Ensuring the unity of measurements.
Topic 12. Metrological certification of measuring devices.
Lecture 16. Metrological certification of measuring devices.
Metrological examination of design and technological documentation. Certification of measuring devices. Certification of measuring devices.
Lecture 17. Metrological chain of transmission of the measurement unit. Verification schemes of measuring devices.Topic 13. Metrological support of production.
Lecture 18. Metrological support of production.
Types of technical control. System of technical control at the enterprise. Statistical control methods. Levels of strictness of control. Confidence intervals of estimates. Control volumes and determination of sampling for product lot control.
Metrological service. Scheme of the state metrological service. Main metrological organizations, their subordination. Metrological service at the enterprise

Laboratory classes
The main tasks of the cycle of laboratory classes are to teach students to apply the acquired theoretical knowledge to calculate the metrological characteristics of measuring devices, in particular, various measurement errors, processing the results of multiple measurements, etc.

Section 1. Fundamentals of metrology and standardization.
Topic 2. Measured quantities, their values and units.
Topic 3. The Unified International System of Measurement Units.
Laboratory class 1. Dimensions of physical quantities, dimensional equations. Conversion of units of measurement from one system to another.

Topic 4. Measuring equipment.
Laboratory class 2. Static characteristics of measuring instruments. Metrological characteristics of measuring instruments.

Section 2. Measurement errors.Topic 7. Errors of measurement tools.
Laboratory class 3. Calculation of errors of measuring instruments. Part 1.
Laboratory class 4. Calculation of errors of measuring instruments. Part 2.

Section 3. Processing of measurement results.

Topic 10. General issues of processing measurement results.
Laboratory class 5. Point assessment. Interval assessment.

Topic 11. Methods of processing measurement results.
Laboratory class 6. Determination of the law of distribution of measurement results.
Laboratory class 7. Assessment of the reliability of measurement results. Detection of mistakes and gross errors.
Laboratory class 8. Processing of direct and indirect measurements.
Laboratory class 9. Processing of aggregate and compatible measurements.

Individual tasks

Calculation and graphic work (CGR) is provided as an individual task.

The purpose of the CGR: checking the ability of students to apply the acquired knowledge in solving problems of a practical nature. A list of tasks will be provided.

Laboratory classes are performed according to the schedule provided by the teacher.

1. Independent work of the student

Independent work of students includes preparation for classroom classes, calculations of tasks for laboratory classes, solving CGR tasks.

Policy and control

2. Policy of academic discipline (educational component)

Forms of organization of the educational process, types of training classes and assessment of training results are regulated by the Regulation on the organization of the educational process at the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute".
Grading policy: each grade is assigned in accordance with the criteria developed in advance and announced to students, as well as motivated individually at the request of the student; if the student does not complete all types of classes provided by the curriculum, he will not be admitted to the exam; missed laboratory classes must be made up in accordance with the teacher's consultation schedule
Attendance is mandatory (except when there is an important reason, such as illness or permission from the dean's office). If the student is unable to attend the classes, he is still responsible for completing the tasks performed in the laboratory classes.
The procedure for enrolling missed classes. Making up for a missed lesson is done by independently completing the task and defending it in accordance with the teacher's consultation schedule.
Policy of academic behavior and integrity: conflict situations should be openly discussed in academic groups with the teacher, it is necessary to be mutually tolerant, to respect the opinion of others. Plagiarism and other forms of dishonest work are unacceptable. Citation in written works is allowed only with a corresponding reference to the author's text. Hints and writing off are not allowed when performing laboratory work and examination work.
Norms of academic ethics: discipline; observance of subordination; honesty; responsibility; working in the classroom with mobile phones switched off or on silent mode. Respect for each other makes it possible to more effectively achieve the set team results. A student can use a laptop when performing laboratory work.
Observance of the academic integrity of students and teachers is regulated by the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute", the Regulations on the Organization of the Educational Process at KPI named after Igor Sikorsky.

3. Types of control and rating system for evaluating learning outcomes

Current control:
performance of laboratory work
The laboratory work is assessed in 5 points:

• complete and timely completion of the task without errors - 5 points;
• complete and timely completion of the task with minor errors - 4 points;
• there are certain shortcomings in the preparation and/or performance of the work - 3 points;
• work not completed - 0 points.

Calculation and graphic work.
It is evaluated with 25 points and consists of 5 tasks.
The weight point of each task is 5.
The student receives 5 points for each task (task) for a report with a detailed explanation and the correct progress of the tasks. If some minor mistakes are made while solving the problem, the student gets 4 points. In case of one significant error, the student receives 3 points for the task. If the answer is not comprehensive, as well as in the absence of a solution to the problem, the student receives 2 points for the problem. If there is an incorrect answer, as well as if there is no solution to the task, the student receives 1 point.

Calendar control

It is conducted twice a semester as a monitoring of the current state of meeting the requirements of the syllabus.
The condition for a positive first calendar control is to obtain at least 27 points, and for the second - to obtain at least 45 points.

Semester control – exam

The sum of the weighted points of control measures during the semester is RS = 70 points.
Exam - RE=30 points.
Thus, the rating scale for the discipline is:
R = RS + RE = 100 points..

Students who scored the required number of points during the semester (RD ≥ 0.9R), i.e. more than 63 points, have the opportunity to:
- get a credit score by the so-called "automark" in accordance with the obtained rating;
- perform attestation examination control work in order to increase the assessment;
The examination paper contains three questions.
Each question is valued at 10 points according to the following criteria:
- "excellent" - a complete answer (at least 90% of the required information), appropriate justifications are provided - 10 - 8 points;
- "good" - a sufficiently complete answer (at least 75% of the required information), completed in accordance with the requirements for the "skills" level, or minor inaccuracies - 7...5 points;
- "satisfactory" - an incomplete answer (at least 60% of the required information), completed in accordance with the requirements for the "stereotypical" level and some errors - 4...2 points;
- "unsatisfactory" - unsatisfactory answer - 0 points.

Table of correspondence of rating points to grades on the university scale:

Scores	Rating
100-95	Excellent
94-85	Very good
84-75	Good
74-65	Satisfactory
64-60	Sufficiently
Less than 60	Unsatisfactory
The conditions are not fulfilled	Not allowed

Working program of the academic discipline (syllabus):

Compiled by: prof. Korobko Ivan Vasyliovych; Ph.D., associate professor Grishanova Iryna Arkadiivna, Viktoriya Vitalyivna Pavlova

Approved by the Department of Space Engineering (protocol No. 15 dated June 7, 2023)

Agreed by the Methodical Commission of the ES IAT (protocol No. 6 dated June 22, 2023)