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

Ecology and technology of plant polymers

Compliance assessment and measurement accuracy assurance

Working program of the academic discipline (Syllabus)

Details of the academic discipline	
Level of higher education	***Second (master's)***
Branch of knowledge	*16 Chemical and bioengineering*
Specialty	***161 Chemical technologies and engineering***
Educational program	*Industrial ecology and resource-efficient clean technologies*
Discipline status	*Selective*
Form of education	*full-time (day)/distance/mixed*
Year of training, semester	*1st year, spring semester*
Scope of the discipline	*4.0 credits (120 hours)*
Semester control/ control measures	*Test*
Lessons schedule	*2 hours per week (1 hour of lectures + 1 hour of practical classes)*
Language of teaching	*Ukrainian*
Information about the course leader / teachers	Lecturer: https://eco-paper.kpi.ua/pro-kafedru/vykladachi/vizytky/Ploskonos-Victor-Grigorovych.html Practical / Seminar: https://eco-paper.kpi.ua/pro-kafedru/vykladachi/vizytky/ Ploskonos-Victor-Grigorovych.html
Placement of the course	*https://do.ipo.kpi.ua/course/view.php?id=4395*

Program of educational discipline

1. Description of the educational discipline, its purpose, subject of study and learning outcomes

The knowledge acquired in the process of studying the academic discipline provides an opportunity to acquire the skills of the basics of metrology and support in the appropriate condition of the measuring equipment (MT) for the proper metrological support of the technological processes of plant raw materials processing. The ability to process and analyze and apply the basics of measurement accuracy during experimental research is formed; statistical analysis of repeated measurements performed in industrial and laboratory conditions.

The subject of the academic discipline "Assessment of conformity and ensuring the accuracy of measurements"*- this is mastering the basics of metrological support and using the acquired knowledge in the process of performing experimental research. Life experience shows that no research, no matter how carefully it is conducted, cannot be performed without knowledge of the basics of metrology, as well as mathematical treatment of the experiment and the accuracy of measurement and evaluation of results.*

To a large extent, the solution of the set tasks will be determined by the level of training of specialists who solve the issue of resource conservation, including scientific institutions and organizations, enterprises.

In order to successfully solve tasks, specialists must be fluent in information, able to solve complex problems of modeling situations at the highest scientific level.

The purpose of the educational discipline "Assessment of conformity and ensuring the accuracy of measurements"

The purpose of the academic discipline is to form students' competencies:

- ability to generate new ideas (creativity);

- the ability to research, classify and analyze indicators of the quality of chemical products, technological processes and equipment of chemical production;

- the ability to use the results of scientific research and R&D to improve existing and/or develop new technologies and equipment for chemical industries.

1.2. According to the requirements of the program of the educational discipline "Evaluation of conformity and ensuring the accuracy of measurements", after mastering it, students must demonstrate the following learning outcomes:

- develop and implement projects in the field of chemical technologies and related interdisciplinary projects taking into account social, economic, environmental and legal aspects;

- search for the necessary information in scientific and technical literature, patents, databases, and other sources on chemical technology, processes and equipment for the production of chemical substances and materials based on them, systematize, and analyze and evaluate the relevant information.

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

Studying the discipline"Evaluation of conformity and ensuring the accuracy of measurements" is based on the principles of integration of various knowledge acquired by students during the bachelor's and the 1st semester of master's studies during the study of engineering disciplines. The discipline "Evaluation of conformity and assurance of accuracy of measurements" is the basis that should ensuresolving a technical problem and is aimed at a deep rethinking of the existing and creation of new holistic knowledge and professional practice.

3. Content of the academic discipline

CHAPTER 1 Conformity Assessment and ENSURING ACCURACY OF MEASUREMENTS

Topic 1 Measurable fphysical values. Principles and methods of measuring physical quantities

Measured physical quantities. Principles and methods of measuring physical quantities. Basic concepts of probability theory and statistics.

Topic 2Preliminary acquaintance with the accuracy of measurements

Mistakes are like mistakes. The inevitability of errors. How important it is to know mistakes. Estimation of the error when counting from the scale. Estimation of errors in the case of multiple direct measurements.

Topic 3The main provisions of ensuring the accuracy of measurements

Best estimate ± deviation. Significant numbers with defined deviations. The difference between the measurement results. Comparison of two values: measured and theoretically known. Comparison of two measured values. Multiplication of two measured values.

Topic 4Statistical analysis of multiple measurements with random deviations

The sum and difference of the measured values. Multiplication and division of measured quantities. Multiplication of the measured value by an exact number. Raising the measured value to the power. Generalizing formulas for calculating the sum, difference, product, and fraction of measured values. Accuracy of measurements using a satisfactory function of one variable. Step-by-step accuracy calculation method. The general formula for calculating the accuracy of measurements in indirect measurements.

Topic 5Statistical analysis of multiple measurements

Random and systematic errors. Average value and standard deviation. Standard deviation is like the error of a unit measurement. Standard deviation of the mean. Systematic errors for experimental research in educational laboratories.

Topic 6Normal distribution of statistical value

Histograms and distribution of random variables. Limit distribution of random variables. The normal distribution of a random variable.

Topic 7Justification of error calculation formulas based on the law of normal distribution

Standard deviation as 68% confidence interval. Justification of the average $\overline{x}$ as the best estimate and σ - the width of the marginal distribution.

Topic 8Calculation and justification of the confidence interval

Calculation and justification of the confidence interval.

Topic 9The problem of screening and combining measurement results

The problem of sifting data. Chauvet's criterion. The problem of combining the results of different measurements.

Topic 10The χ2 criterion for marginal distributions

The concept of the χ2 criterion. Degrees of freedom and reduced value of χ2. Probabilities for χ2.

Topic 11 Methods of assessing the accuracy of measurements based on the concept of uncertainty

General concepts and definitions of the concept of uncertainty. An example of estimating error characteristics and calculating measurement uncertainty. Comparative analysis of two approaches to determining the characteristics of measurement accuracy.

4. Educational materials and resources

Basic literature

1. Yermilova N.V., Kyslytsia S.G. "New sources of standardization and methodology" : Study guide / – Poltava: PoltNTU, 2017. - 141 p.

2. Nesterchuk D.M., Kvitka S.O., Halko S.V.. Fundamentals of metrology and measuring tools: a study guide / – Melitopol: Publishing and printing center "Lux", 2017. - 256 p.

3. Bozhenko L.I. Metrology, standardization, certification and accreditation. – Lviv: Afisha, 2006. - 324 p.

4. Vasilevskyi O.M., Kucheruk V.Yu., Volodarskyi E.T. Fundamentals of the theory of measurement uncertainty: Textbook / – Vinnytsia: VNTU, 2015. – 230 p.

Additional literature

5. Law of Ukraine on metrology and metrological activities, No. 1765, Kyiv, June 15, 2004.

6. DSTU 3410-96 UkrSEPRO certification system. Substantive provisions.

7. Volodarskyi Y.T., Kuharchuk V.V., Podzharenko V.O., Serdyuk G.B. Metrological support of measurements and control. Study guide for technical students. university - Vinnytsia: Published. State, Technical University, 2001.-220 p.

8. DSTU 3651.2-97 Metrology. Units of physical quantities. Basic units of physical quantities. International systems of values. Basic provisions, names and designations.

10. Primakov SP., Barbash V.A. Technology of paper and cardboard. K.: ECMO, 2002.-396 p.

11. DSTU 2926-94 Quality systems. Complexes of quality management are system and technological. Substantive provisions.

Information resources on the Internet

Electronic resources from the course"Evaluation of conformity and ensuring the accuracy of measurements", namely:

- *credit module syllabus,*
- *methodical instructions for performing laboratory practicals and performing independent work*

located athttp://www.eco-paper.kpi.ua/for-student, as well as in the e-campus

Association of Ukrainian pulp and paper enterprises "UkrPapir"- ***ukrbim@naverex.kiev.ua***

Educational content

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

Lecture classes

Lectures are aimed at:

- provision of modern, integral, interdependent knowledge in the discipline "Evaluation of conformity and ensuring the accuracy of measurements", the level of which is determined by the target setting for each specific topic;

- ensuring creative work of students together with the teacher during the lecture;

- education of students' professional and business qualities and development of their independent creative thinking;

- forming the necessary interest in students and providing direction for independent work;

- definition at the current level of scientific development in the field of standardization, metrology and accuracy of measurements;

- reflection of the methodical processing of the material (highlighting of the main provisions, conclusions, recommendations, their wording is clear and adequate);

- the use of visual materials for demonstration, combining them, if possible, with the demonstration of research results;

- teaching research materials in a clear and high-quality language with observance of structural and logical connections, clarification of all newly introduced terms and concepts;

- accessibility for perception by this audience.

No. z/p	*The name of the topic of the lecture and a list of the main questions (a list of didactic tools, references to the literature and tasks on the IWS)*	*Hour*
1	***SECTION 1. ASSESSMENT OF COMPLIANCE AND ENSURING ACCURACY OF MEASUREMENTS*** ***Topic 1 Measurable physical quantities. Principles and methods of measuring physical quantities*** ***Topic 2 Preliminary acquaintance with the accuracy of measurements*** *Lecture No. 1. Measurable physical quantities. Principles and methods of measuring physical quantities. Basic concepts of the theory of probabilities and statistics. Errors are like errors. The inevitability of errors. How important it is to know mistakes. Estimation of the error when counting from the scale. Estimation of errors in the case of multiple direct measurements.* *Literature: [5] pp. 21-29; [7] pp. 16-21; [8] pp. 25-37.* *Tasks on IWS. Systems of physical quantities and their units. Accuracy indicators and forms of presentation of measurement results. General provisions and classification of errors.*	*2*
2	***Topic 3 Basic provisions of measurement accuracy*** *Lecture No. 2. Best estimate ± accuracy. The difference between the measurement results. Comparison of two values: measured and theoretically known. Comparison of two measured values. Comparison of two values: measured and theoretically known. Comparison of two measured values. Relative errors. Significant figures in relative errors. Multiplication of two measured values* *Literature: [5] p.31-57; [7] pp. 23-54; [8] pp. 39-68.* *Tasks on IWS. Comparison of two values: measured and theoretically known. Comparison of two measured values.*	*2*

3	***Topic 4Accuracy in indirect measurements*** *Lecture No. 3. Errors of the sum and difference of measured quantities. Multiplication and division of measured quantities. Multiplication of the measured value by an exact number. Raising the measured value to the power.* *Lecture No. 4. Independent errors when calculating the sum of measured values. Generalizing formulas for calculating the sum, difference, product, and fraction of measured values with independent errors. Errors when using a satisfactory function of one variable. Step-by-step error calculation method. General formula for calculating errors in indirect measurements.* *Literature: [5] p.61-77; [7] pp. 63-85; [8] pp. 69-88.* *Tasks on IWS. General information about errors in indirect measurements. Understanding errors in indirect measurements using examples. The principle of the arithmetic mean.*	***4***
4	***Topic 5Statistical analysis of multiple measurements with random errors*** *Lecture No. 5. Random and systematic errors. Average value and standard deviation. Standard deviation is like the error of a unit measurement. Standard deviation of the mean. Systematic errors for experimental research in educational laboratories.* *Literature: [5] c.106-130, [10] c.54-72, [6] c. 88-101.* *Tasks on IWS. Determination of the guarantee interval of measurement results. Summary of measurement errors. Errors of direct equal-precision measurements. Processing and assessment of the accuracy of exact measurements. Standard deviation of the mean in examples.*	***2***
5	***Topic 6Normal distribution of statistical value***. ***Topic 7 Justification of error calculation formulas based on the law of normal distribution*** ***Topic 8 Calculation and justification of the confidence interval*** *Lecture No. 6. Histograms and distribution of random variables. Limit distribution of random variables. The normal distribution of a random variable. Standard deviation as 68% confidence interval. Justification of the average* $\bar{x}$ *as the best estimate and* σ *- the width of the marginal distribution. Justification of the calculation of errors in indirect measurements. Justification of the standard deviation of the mean. Calculation and justification of the confidence interval.* *Literature: [5] c.136-155, [3] c.54-72, [6] c. 123-155; [7] c. 108-123, [10] c. 88-101.* *Tasks on IWS. The law of probability distribution for multiple measurements. Random variables. The use of elements of the theory of probabilities to the results of measurements. Repetition of tests - binomial distribution. Quadratic sum of errors and its justification. General case. Determination of the mean squared error. Confidence intervals. The required number of random variable measurements.*	***2***
6	***Topic 9The problem of screening and combining measurement results*** *Lecture No. 7. The problem of data screening. Chauvet's criterion. The problem of combining the results of different measurements.* *Literature: [5] c. 178-192; [13] c. 98-137.* *Tasks on IWS. The problem of data screening using the Chauvenet criterion on examples. The problem of combining the results of various measurements on examples.*	*2*

7	***Topic 10 Criterion χ2 for marginal distributions*** ***Topic 11 Methods of assessing the accuracy of measurements based on the concept of uncertainty*** *Lecture No. 8. Concept of the χ2 criterion. Degrees of freedom and reduced value of χ2. Probabilities for χ2.. General concepts and definitions of the concept of uncertainty. An example of estimating error characteristics and calculating measurement uncertainty. Comparative analysis of two approaches to determining the characteristics of measurement accuracy.* *Literature: [6] c. 168-182.* *Tasks on IWS. Linear correlation coefficient. quantitative criterion of significance r. Comparative analysis of two approaches to determining the characteristics of measurement accuracy.*	*2*
7	*Preparation for HCW*	*2*
	In total	***18***

Practical training

In the system of professional training of students in this discipline, practical classes occupy 25% of the classroom load. They lay and form the foundations of students' qualifications. The content of these classes and the method of conducting them should ensure the development of the creative activity of the individual. They develop scientific thinking and the ability to use special terminology, allow you to check knowledge, therefore this type of work is an important means of operational feedback. Practical classes should perform not only cognitive and educational functions, but also contribute to the growth of students as creative workers.

The main tasks of the cycle of practical classesand laboratory workshops:

- *help students systematize, consolidate and deepen knowledge of a theoretical nature in the field of standardization, metrology and accuracy of measurements;*
- *to teachtheir work with scientific and reference literature;*
- *to form skillsto learn independently, that is, to master the methods, methods and techniques of self-learning, self-development and self-control.*

No. z/p	***Name of the subject of the practical session and list of main questions (a list of didactic support, references to the literature and tasks on the IWS)***	***Hour***
1	***Practical lesson 1-2.*** *General concepts of physical quantities. Systems of physical quantities. Clarification of the causes of errors. The main provisions of measurement accuracy. Solving problems for the purpose of general estimation of errors in the case of multiple measurements. Relative errors and significant figures.* *Literature: [5] p12-21; [7] pp. 6-14; [8] p. 16-23.* *Tasks on IWS. Solving problems with the aim of general estimation of errors in the case of repeated measurements in laboratory conditions.*	***4***
2	***Practical lesson 3-4.*** *Errors in indirect measurements. Determining errors when using measurement results in sum, difference, multiplication and division operationsLiterature: [5] c. 49-64; [7] c.16-22.* *Tasks on IWS. Errors in indirect measurements in laboratory conditions.* ***MCT-1 on topics of sections 1-2 - 1 hour.***	***4***
3	***Practical lesson 5-6.*** *Statistical analysis of random errors. Calculation of mean and standard deviation.* *Literature: [5] c.87-91, [7] c.34-43, [8] c. 49-54.* *Tasks on IWS. Calculation of mean and standard deviation in laboratory conditions.*	***4***
4	***Practical lesson 7.*** *Statistical analysis of random errors. Calculation of the standard deviation of the mean. Systematic errors.* *Literature: [5] c.92-101, [10] c.44-63, [13] c. 55-64.* *Tasks on IWS. Calculation of the standard deviation of the mean in laboratory conditions.*	***2***

5	***Practical lesson 8-9.*** *Solving tasks for sifting and combining measurement results.* *Literature: [5] c. 148-152; [8] c. 18-58.* *Tasks on IWS. Screening and combining of measurement results in laboratory conditions in laboratory conditions.* ***MCT-2 on topics of chapter 3 - 1 hour.***	***4***
	In total	***18***

9. Independent work of the student

Independent work takes up 65% of the time of studying the credit module, including preparation for the credit. The main task of students' independent work is the acquisition of scientific knowledge in areas that are not included in the list of theoretical foundations by means of a personal search for information, the formation of an active interest in a creative approach to educational work. In the process of independent work within the framework of the educational component, the student must learn to analyze modern methods of developing mathematical models.

No. z/p	*The name of the topic submitted for independent processing*	*Number of hours of IWS*
Chapter 1 Conformity Assessment and ENSURING ACCURACY OF MEASUREMENTS		
1	***Topic 1 Standardization. Basic concepts. Terms and definitions*** ***IWS to topic 1****Main presults, purpose, principles and objects of standardization.* *Literature: [4] p12-21; [1] pp. 6-14.* ***Topic 2 Topic 2 Classification of regulatory documentation (ND), procedure for development and approval of standards.*** ***IWS to topic 2****Basics of standardization. National standardization system. Scientific and methodical bases of standardization. Organization of work on standardization in Ukraine. The essence of standardization and its role in increasing the efficiency of the development of the national economy. Classification and coding of scientific, technical, economic and social information.* *Literature: [2] pp. 34-41; [4] pp. 29-44.* ***Topic 3 Organization of standardization work in Ukraine.*** ***IWS to topic 3****Financing of standardization works. Information provision of standardization, its services and ownership of standards. Improvement of the state standardization system and Ukraine's entry into the WTO. Harmonization of standards.* *Literature: [2] pp. 43-51; [4] pp. 46-54.* ***Topic 4 Standardization in international organizations*** ***IWS to topic 4****Prospects of international standardization.* *Literature: [2] p.44-64; [4] pp. 59-74.* ***Topic 5 Standardization in foreign countries*** ***IWS to topic 5****Standardization in France. Standardization in Germany. Standardization in Japan.* *Literature: [2] p.66-79; [4] pp. 49-64.* ***Topic 6 Basic provisions of the technological regulations and TU U in Ukraine*** ***IWS to topic 6****Procedure for development, approval and implementation of technological regulations. Terms. Composition of technological regulations. Requirements for the content of the main section of the technological regulation. Procedure for developing technological regulations. The procedure for drawing up technological regulations. The procedure for agreeing technological regulations. The procedure for approval and registration of technological regulations. Term of validity of the technological regulation. The procedure for canceling the technological regulation. Monitoring of implementation and responsibility for violations of technological regulations;* *(Technological regulation of newsprint production.*	*24*

	Literature: [4] p.69-84. ***Topic 7 Regulations on conformity of products in Ukraine.*** ***IWS to topic 7****Funding of compliance activities. International cooperation of Ukraine in the field of compliance verification.* *Literature: [4] p.86-104, [17] p.16-45.* ***Topic 8 Testing laboratories for products*** *Quality system. Products and products being tested. Testing equipment and measuring equipment. Accreditation of testing laboratories. Inspection control over the activities of accredited laboratories.* ***IWS to topic 8****Quality system. Products and products being tested. Testing equipment and measuring equipment. Accreditation of testing laboratories. Inspection control over the activities of accredited laboratories.* *Literature: [4] p.108-126; [6] p.19-35, [17] p.66-83.*	
2	***Topic 1 The essence of metrological assurance of product conformity assessment. Tasks and functions of metrological assurance of product conformity assessment.*** *IWS to topic 1 Principles and methods of measuring physical quantities.* *Literature: [1] p.10-23; [2] p.6-14, [3] p.7-19, [4] p.128-134.* ***Topic 2. Means of measuring technology (MET), classification of MT and their purpose*** *IWS to topic 2 Accuracy indicators and forms of presentation of measurement results.* *Literature: [1] pp. 30-43; [2] pp. 16-34, [4] pp. 137-149, [14] pp. 28-44.* ***Topic 3 State metrological service of Ukraine*** *IWS to topic 3 Law on metrology: basic concepts and definitions.* ***Topic 4****Metrological assurance of unity and accuracy of measurements. State metrological control and supervision. Metrological service of the enterprise* *IWS to topic 4 State metrological service of the enterprise (organization).* *Literature: [2] p.48-66; [3] pp. 56-74, [4] pp. 166-184, [14] pp. 68-86.* ***Topic 5 Metrological attestation, verification and calibration of measuring equipment. Methods of verification of FTAs*** *IWS to topic 5 Metrological verification of measuring equipment. Types of metrological checks. Organization and procedure of metrological verification.* *Literature: [2] p.68-96; [3] pp. 76-94, [4] pp. 186-199, [14] pp. 88-106.* ***Topic 6 International metrology organizations. Metrology in foreign countries*** *IWS to topic 6 Metrological examination of technical documentation. General provisions and tasks of metrological examination. Organization and procedure of metrological examination. Metrological examination of design documentation. Metrological examination of technological documentation.* *Literature: [2] p.98-126; [3] pp. 96-124, [4] pp. 202-249, [14] pp. 108-136.*	*24*
3	***Topic 1 Measurable physical quantities. Principles and methods of measuring physical quantities*** *IWS to topic 1 Systems of physical quantities and their units. Accuracy indicators and forms of presentation of measurement results. General provisions and classification of errors.* *Literature: [5] pp. 12-19; [7] pp. 6-14; [8] pp. 5-17.* ***Topic 2 Preliminary acquaintance with the accuracy of measurements*** *IWS to topic 2 General provisions and classification of errors.* *Literature: [5] pp. 21-29; [7] pp. 16-21; [8] pp. 25-37.* ***Topic 3 Basic provisions of measurement accuracy*** *IWS to topic 3 Comparison of two values: measured and theoretically known. Comparison of two measured values.* *Literature: [5] p.31-57; [7] pp. 23-54; [8] pp. 39-68.* ***Topic 4 Errors in indirect measurements*** *CRC to topic 4 General information about errors in indirect measurements. Understanding errors in indirect measurements using examples. The principle of the arithmetic mean.*	*24*

	Literature: [5] p.61-77; [7] pp. 63-85; [8] pp. 69-88. ***Topic 5Statistical analysis of multiple measurements with random errors*** *IWS to topic 5 Determination of the guarantee interval of measurement results. Summary of measurement errors. Errors of direct equal-precision measurements. Processing and assessment of the accuracy of exact measurements. Standard deviation of the mean in examples.* *Literature: [5] c.106-130, [10] c.54-72, [6] c. 88-101.* ***Topic 6Normal distribution of statistical value*** *IWS to topic 6 The law of probability distribution for multiple measurements. Random variables. The use of elements of the theory of probabilities to the results of measurements. Repetition of tests - binomial distribution.* *Literature: [5] c.136-155, [3] c.54-72, [10] c. 88-101.* ***Topic 7 Justification of error calculation formulas based on the law of normal distribution*** *IWS to topic 7 Quadratic sum of errors and its justification. General case. Determination of the mean squared error.* *Literature: [5] c. 148-172; [7] c. 78-95.* ***Topic 8 Calculation and justification of the confidence interval*** *CRC to Topic 8 Confidence Intervals. The required number of random variable measurements.* *Literature: [6] c. 123-155; [7] c. 108-123.* ***Topic 9 The problem of screening and combining measurement results*** *IWS to topic 9 The problem of screening data using the Chauvenet criterion with examples. The problem of combining the results of various measurements on examples.* *Literature: [5] c. 178-192; [13] c. 98-137.* ***Topic 10 Criterion χ2 for marginal distributions*** *IWS to topic 10 Coefficient of linear correlation. quantitative criterion of significance r.* *Literature: [5] c. 198-222; [7] c. 218-141.* ***Topic 11 Methods of assessing the accuracy of measurements based on the concept of uncertainty*** *IWS to topic 11 Comparative analysis of two approaches to determining the characteristics of measurement accuracy.* *Literature: [6] c. 168-182.*	
5	***Preparation for MCT***	*2*
6	*Preparation for the test*	*10*
	Hours in general	*84*

Policy and control

10. Policy of academic discipline (educational component)

Rules of attending classes and behavior in classes

Attending classes is a mandatory component of the assessment. Students are obliged to take an active part in the educational process, not to be late for classes and not to miss them without a good reason, not to interfere with the teacher conducting classes, not to be distracted by activities unrelated to the educational process.

Rules for assigning incentive and penalty points

- *incentive points can be awarded by the teacher exclusively for the performance of creative works in the discipline or additional completion of online specialized courses with the receipt of the appropriate certificate:*
- *https://www.coursera.org/learn/research-methods;*
- *https://ru.coursera.org/learn/metodologiya-nauchnyh-issledovanij-kotiki.*

But their sum cannot exceed 10% of the rating scale.

- *Penalty points are not provided within the academic discipline.*

Policy of deadlines and rescheduling

In the event of arrears from the academic discipline or any force majeure circumstances, students should contact the teacher through available (provided by the teacher) communication channels to resolve problematic issues and agree on the algorithm of actions for practice.

Policy of academic integrity

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism includes the absence of references for the use of printed and electronic materials, quotes, opinions of other authors. Inadmissible tips and write-offs during writing tests, conducting classes; passing a test for another student; copying materials protected by the copyright system without the permission of the author of the work.

The policy and principles of academic integrity are defined in Chapter 3 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute". More details:https://kpi.ua/code

Policy of academic behavior and ethics

Students should be tolerant, respect the opinion of others, formulate objections in the correct form, constructively support feedback during classes.

Standards of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute". More details:https://kpi.ua/code

8. Types of control and rating system for evaluating learning outcomes (RSO)

Distribution of study time by types of classes and tasks in the discipline according to the working curriculum:

Semester	Training time		Distribution of study hours				Control measures		
	Credits	Acad. hours	Lectures	Practical	Lab. practice	IWS	MCT	HCW	Semester control
3	4.0	120	18	18	-	84	1	1	Test

The student's rating in the discipline consists of the points he receives for:

The student's credit module rating consists of the points he receives for:

1) implementation and defense of 9 practical works;

2) two control papers (one MCT is divided into MCT-1, MCT-2) with a duration of one academic hour each);

3) implementation of the HCW.

Semester control is credit.

1 We choose the "hard" version of RSO-1

2 Calculations of approximate values of weight points from each control measure

Next, the approximate values of the weight points for each control measure are calculated.

First of all, it is necessary to determine the value of tk - the educational time planned in the work program for the assimilation of educational material (knowledge and skills), which should be controlled by the k-th control measure.

2.1 Work in practical classes:

Each practical session is provided (on average) with two lectures and the corresponding IWS time, therefore, when determining tl, we take into account 6 hours. classroom classes and 6 hours IWS related to these classes. Thus, tl = 14 hours.

2.3 Two ICRs provide verification of all educational material. Therefore, we take into account all the time spent on mastering the academic discipline, with the exception of 6 hours for credit. Thus, tmcr = 138 : 2 = 69 h.

2.4 HCW provides verification of all educational material. Therefore, we take into account all the time spent on mastering the academic discipline, with the exception of 6 hours for credit. Thus, tmcr = 138 : 2 = 69 h.

3 Determination of approximate values of the corresponding weight points

Approximate values of the corresponding weight points are determined based on the calculation of the 100-point scale of RSO:

Σ tk = tp × 3 + tl × 9 + tMCT × 3 = 12 × 3 + 14 × 9 + 69 × 2 = 300;

rp = 12 × 100 / 300 = 4.0; rl = 14 × 100 / 300 = 4.66; rMCT = 69 × 100 / 300 = 23.0.

We finally determine weight points.

4 × 3 + 4.7 × 9 + 23 ×2 should equal 100 points. Therefore, let's make a certain correction:

rp = 5; rHCW = 1 5 rMCT = 20.

4*Determination of the scale of points for the corresponding levels of assessment for each type of control*

A scale of points is determined for the corresponding levels of assessment for each type of control. Taking into account the threshold values of 0.9 – 0.75 – 0.6 – 0, we have the following distribution:

a) Practical work.

Good work, correctly designed result, good and timely defense of work - 5 points;

1 point (but not more than 2 points) is deducted for a decrease in the indicator for one of the positions.

b) Modular control work.

"excellent" - 20 points;

"very good" - 17 points;

"good" - 15 points;

"satisfactory" - 12 points;

"unsatisfactory" - 0 points.

c) Home test work.

"excellent" - 15 points;

"very good" - 13 points;

"good" - 11 points;

"satisfactory" - 9 points;

"unsatisfactory" - 0 points.

A control check is carried out, namely: a student who received the minimum positive points for all controls will have at least 60 points in the end.

3 × 9 + 9+12 ×2 = 60 points.

System of rating points

<u>1. Practical work</u>

- *under the condition of good work, correctly drawn up protocol, good and timely defense of work - 5 points;*

1 point (but not more than 2 points) is deducted for a decrease in the indicator for one of the positions.

In case of non-admission to laboratory work due to unsatisfactory input control, a penalty (–1) point is charged.

2. Modular control work

- *"excellent", complete answer (at least 90% of the required information) - 20 points;*
- *"very good", a sufficiently complete answer (at least 80% of the required information), or a complete answer with minor inaccuracies - 17 points;*
- *"good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 15 points;*
- *"satisfactory", incomplete answer (at least 60% of the required information) and minor errors - 12 points;*

"unsatisfactory", an unsatisfactory answer (does not meet the requirements for "satisfactory") - 0 points.

3. Home test work

- *"excellent", complete answer (at least 90% of the required information) - 15 points;*
- *"very good", a sufficiently complete answer (at least 80% of the required information), or a complete answer with minor inaccuracies - 13 points;*
- *"good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 11 points;*
- *"satisfactory", incomplete answer (at least 60% of the required information) and minor errors - 9 points;*

"unsatisfactory", an unsatisfactory answer (does not meet the requirements for "satisfactory") - 0 points.

According to the results of educational work in the first 7 weeks, the "ideal student" should score 40 points.

At the first certification (8th week)*a student is "enrolled" if his current rating is at least 0.5 x 40 = 20 points.*

According to the results of 13 weeks, the "ideal student" should score 80 points.

On the second certification (week 14)*a student is "enrolled" if his current rating is at least 0.5 x 80 = 40 points.*

The maximum number of points is 100.

A necessary condition for admission to the credit is the enrollment of all practical works, all MCT and HCW.

To receive credit from the credit module "automatically" you need to have a rating of at least 60 points.

Students who score on the grading scale of F (40 points or less) are not allowed to take credit and must improve their rating.

Students who scored 41-59 (Fx score) or those who wish to improve their score take a credit test. At the same time, points earned during the semester are cancelled.

During the test, students answer 3 questions, each of which is worth 34 points.

The maximum number of points is 34 x 3 = 100 points.

Criteria for evaluating students' knowledge in the final test:

Completeness and signs of response	***Points***
"Excellent" is the complete answer to the question (at least 90% of the required information)	*34...32*

"Very good", a sufficiently complete answer to the question (at least 80% of the required information), or a complete answer with minor inaccuracies	*29...27*
"Good", a sufficiently complete answer to the question (at least 75% of the required information), or a complete answer with minor inaccuracies	*26...25*
"Satisfactory", incomplete answer to the question (at least 60% of the required information) and minor errors	*21...20*
"Unsatisfactory", unsatisfactory answer to the question (does not meet the requirements for "satisfactory")	*0*

Rating assessment from the credit control work:

R	*University scale*
95...100 points	*Perfectly*
85...94 points	*Very good*
75...84 points	*Fine*
65...74 points	*Satisfactorily*
60...64 points	*Enough*
R<60 points	*Unsatisfactorily*
If rc<40 points or other admission conditions are not met	*Not allowed*

11. Additional information on the discipline (educational component)

List of questions of modular control works

Modular control work (mcr-1)

1. Define what STANDARDIZATION is.
2. Define what a STANDARD is.
3. Define which spheres of activity and forms of ownership are covered by the Law of Ukraine "On Standardization"?
4. Define what is the main task of standardization?
5. Define what is the essence of standardization?
6. Define what is the priority direction of standardization in Ukraine?
7. Bringtypes of standards depending on the objects of standardization?
8. Bringtypes of standards depending on the level of the subject of standardization that adopted the standard?
9. Show how long the standards that were used during the production of products should be kept?
10. Name the standardization bodies established by the Law "On Standardization".
11. leadWhat is the national mark of conformity of products to national standards?
12. Name the main tasks of state control and supervision of compliance with the mandatory requirements of standards.
13. Show who carries out state control and supervision of compliance with the mandatory requirements of the standards?
14. What is harmonization of standards?

15. Bringgenerally recognized task of ISO ?
16. leadwhat is the national standards body in uk ?
17. leadWhat is the national standardization body in the Russian Federation?

Modular control work (mcr-2)

1. Define metrology as a science.
2. What are the main tasks of metrology?
3. Show what problems the tasks of metrology are aimed at solving?
4. In accordance with tasks and functions, what types of metrology can be called?
5. In accordance with the law "On metrology and metrological activities" define the unity of measurements.
6. Name the main organization for ensuring the unity of measurements in Ukraine.
7. leadthat refers to departmental metrological services of Ukraine?
8. Define the measuring equipment.
9. List the types of measuring equipment?
10. Show why all FTAs are subject to mandatory state departmental verification?
11. leadWhat constitutes the basis of the state system of ensuring the unity of measurements?
12. Define what is called metrological support?
13. Bringat the expense of what is the unity of measurements achieved and the determination of unanimity of the FTA?
14. Show what constitutes the technical basis of metrological support?
15. leadWhat are the objects of State control and supervision?
16. Show what belongs to the functions of departmental metrological control?
17. Name the international metrological organizations that made and are making a significant contribution to solving the problems of the unity of measurements.

An approximate list of questions that are submitted for semester control:

1. *Justify the concept and provide a formula for calculating the relative error.*
2. *To justify the concept of measurement accuracy through relative error.*
3. *To justify the use of the concept of relative error in the formula for calculating the error of obtaining measurement results.*
4. *Analyze and provide a rule for calculating the error of the sum and difference of two independent measured values.*
5. *Analyze the error calculation rules used when measuring independent measured quantities.*
6. *Analyze and provide the rule for calculating the error of the sum and the difference of values, the rule for the error of the product and division of the measurement results, as well as the rule for the product of the measurement result by an exact number.*
7. *To justify the use of the rule for calculating the error when raising the measured value to the power.*
8. *Analyze and provide a formula for estimating the error when using a satisfactory function of one variable in cases of indirect measurements.*
9. *To justify the use of the general formula for calculating errors in indirect measurements and the step-by-step method.*
10. *To justify the essence of the problem of combining the results of the experiment and to decide on the formulas for calculating the weighted average.*

11. *Define what the difference between measurement results is, give an estimate of the significance (insignificance) of the difference, based on the concept of best estimate and error.*
12. *Analyze and provide a formula for calculating the standard deviation of the mean.*
13. *Analyze and provide a rule for calculating the error of the difference of measurement results.*
14. *Analyze and provide formulas for calculating the value of the χ2 criterion.*
15. *To justify the essence of the problem of combining the results of the experiment and to decide on the formulas for calculating the weighted average.*
16. *Analyze and provide a sequence of formulas for calculating a confidence interval.*
17. *To substantiate the scheme of using the Chauvenet criterion.*
18. *To justify the essence of the problem of combining the results of the experiment and to decide on the formulas for calculating the weighted average.*
19. *Analyze and provide formulas for statistical processing of measurement results, namely: calculation of the average value and standard deviation of the average.*
20. *To analyze the error estimation formula using the satisfactory function of one variable in cases of indirect measurements.*
21. *To substantiate the scheme of using the Chauvenet criterion.*
22. *Analyze and provide formulas and determine the sequence (algorithm) of using the formulas to prove whether a certain sample of observations corresponds to the Gaussian normal distribution.*
23. *Analyze and provide formulas for calculating the value of the χ2 criterion.*
24. *Analyze and provide formulas for statistical processing of measurement results, namely: calculation of the average value and standard deviation of the average.*

Tasks

1. Apply the formula for calculating the relative error (in percent) for five measurements:
- measured height = 5.03±0.04 m;
- measured time = 19.5±1 s;
*- measured charge = (-3.2±0.3) *10-19 K);*
*- measured wavelength = (0.56±0.07) *10-6 m);*
*- measured impulse = (3.27±0.04) *103 g*cm/s).*

2. Use the concept of measurement accuracy due to the relative error for the case, namely: suppose that you need to measure a length of 2 cm with an accuracy of 1%. With the help of a wooden ruler, you can count with an accuracy of up to 1 mm, and with the help of a microscope - up to 0.1 mm.
Is it possible to do this with a wooden ruler? With a microscope?

3. Use the formula for calculating the error of measurement results in the case when two values a and b are measured (the length and width of the paper strip for strength testing). We get: a=11.5±0.2 cm and c=25.4±0.2 cm.
*It is necessary to calculate the value of the area of the strip S=a*в, the absolute and relative value of the error in S, as well as the relative value of the errors of the measured values?*

4. Use the rule for calculating the error of the sum and the difference of two independent measured values in the case of:
The laboratory assistant mixes solutions of chemical reagents from two bottles, having previously measured separately the masses of these filled and then empty bottles and obtained as a result:
M1 - mass of the first cylinder and its contents = 540 ±10 g;
m1 = mass of the first empty cylinder = 72 ±1 g;
M2 = mass of the second cylinder and its contents = 940 ±20 g;
m2 = mass of the second empty cylinder = 97 ±1 g.

It is necessary to determine the total mass of chemical reagents, calculate the error of the total mass and record the final result.

5. Use the error calculation rules that are used when measuring independent measured values in the case of:

The specialist received the following measurement results:

a=5±1 cm; in=18±2 cm; c=12±1 cm; t=3.0±0.5 s; m=18±1 g.

Using the error rules of the sum (difference) of the measurement results and the product and division of the measurement results, calculate the errors and relative errors (in %):

*a) a+v+c; b) a+v-c; c) c*t; d) 4a; e)b/2 (where numbers 4 and 2 have no error), f)m*b/t.*

6. Use the calculation rules: errors of the sum and difference of values, errors of the product and division of the measurement results, the product of the measurement result by an exact number when calculating the following expressions:

a) (5±1)+ (8±2)- (10±4); b) (5±1)(8±2);*

c) (10±1)/(20±2); d) 2π(10±1) (the numbers π and 2 have no error).*

7. Use the rule for calculating the error when raising the measured value to the power in the case when the experimenter determines the acceleration of free fall g by measuring the time t of the stone falling from a height h (h is determined by the well-known formula $h=(\frac{1}{2})g*t^2$ *).*

After several time measurements, he finds:

t =1.6 ±0.1 s and measures the height h as h = 14.1 ±0.1 m.

8. Use the error estimation formula using the satisfactory function of one variable in the case: the angle ϑ was measured as 125±2 degrees. This value is then used to calculate Sin(ϑ).

Sin(ϑ) and error must be calculated.

*9 Use the general formula for calculating errors in indirect measurements and the step-by-step method, using the example of calculating a certain value c=a*v:*

a=10.0±0.5N; in=15±1 cm.

10. The experimenter measures the density of the liquid five times and gets the results (in g/cm3): 1.8; 2.0; 2.0; 1.9; 1.8.

What can be said about the best estimate and margin of error based on his measurements?

*11. It is necessary to accurately measure the area (S) of a rectangular paper sample intended for testing with a size of 2.5 cm * 5.0 cm.*

In the table the results of 10 measurements of the width (l) and length (c) of the sample are given.

Dimension size	*Measured values*
L	*24,25; 24,26; 24,22; 24,28; 24,24;*
	24,25; 24,22; 24,26; 24,23; 24,24.
B	*50.36; 50.35; 50.41; 50.37; 50.36;*
	50.32; 50.39; 50.38; 50.36; 50.38.

In order to measure the area (S) of a rectangular paper sample, it is necessary, accordingly, to calculate the average value of both values, the standard deviation σ_x *and standard deviation of the mean* $\sigma_{\bar{x}}$ *using appropriate formulas.*

12. Calculate the errors of the difference of measurement results in order to compare two measured values and use it for the case:

In an experiment to verify the law of conservation of momentum, the student obtained the values given in the table for the initial and final moments (L and L').

Do you need to add additional columns for the difference (L - L') and error to the table and check whether the student's results are consistent with the law of conservation of angular momentum?

Primary (L)	*Final L'*

3.0±0.3	2.7±0.6
7.4±0.5	8.0±1.0
14.3±1.0	16.5±1.0
25±2	24±2
32±2	31±2
37±2	41±2

13. Determine (by filling in the free columns in the table) whether the sample of observations on the growth of 200 aborigines on some island corresponds to the normal Gaussian distribution, given in the table:

Bin number	Growth in bin	The number of observations Ok in the bin	The expected number of Ek	Pk, %
1	less than X-1.5σ	14		
2	between X-1.5σ and X-σ	29		
3	between X-σ and X-0.5σ	30		
4	between X-0.5σ and X	27		
5	between X and X+0.5σ	28		
6	between X+0.5σ and X+σ	31		
7	between X+σ and X+1.5σ	28		
8	greater than X+1.5σ	thirteen		

14. Calculate the confidence interval in the case when the experimenter repeatedly measures g, the acceleration of free fall, and gets a result of 9.5 m/s2 and a standard deviation equal to 0.1.

If we assume that the results of his measurements are normally distributed with a center equal to the accepted value of 9.8 m/s2 and a width of 0.1, then what is the probability of obtaining a result that differs from 9.8 m/s2 as much (or more) as the experimenter's result ?

Assuming that the experimenter did not actually make mistakes, could it be said that his experiment was probably affected by some undetected bias?

15. Two measurements of the destructive force P give the results: 334±1 and 336±2.

Can these two results be considered consistent?

If so, then you need to calculate the best estimate of the indicator P and its error.

16. To determine whether it is necessary to reject a questionable measurement result in the case of:

The specialist measures the thickness of the cardboard H ten times and gets the results (in mm):

0.86; 0.83; 0.87; 0.84; 0.82; 0.95; 0.83; 0.85; 0.89; 0.88.

a) It is necessary to calculate the average value $\overline{H}$ and standard deviation σ_H of these results.

b) If the specialist decides to use the Chauvin test, should he reject the result of 0.95 mm? It is necessary to argue the concession.

17. Use formulas for calculating the average value and standard deviation of the average for the case:

The specialist measures the value of x five times and gets the results: 5, 7, 9, 7, 8.

It is necessary to calculate $\overline{x}$ and standard deviation σ_x. Compare two options (with N and N-1) during the calculation σ_x.

18. Use the error estimation formula for the use of a satisfactory function of one variable in cases of indirect measurements: the angle ϑ was measured as θ=20±3 degrees. This value is then used to calculate Cosθ.

It is necessary to calculate Cosθ and error.

19. To determine whether it is necessary to reject a questionable measurement result in the case of:

The specialist makes 14 measurements of the oscillation period of the generator and receives the results (in fractions of a second): 7, 3, 9, 3, 6, 9, 8, 7, 8, 12, 5, 9, 9, 3

Feeling that the result (12) is too large, the specialist decides to use the Chauvenet criterion. Will he reject this result? How many results similarly different from the mean as 12 should he expect?

20. Use the error estimation formula for the use of a satisfactory function of one variable in cases of indirect measurements: the angle ϑ was measured as θ *=20±3 degrees. This value is then used to calculate Cos* θ*.*

It is necessary to calculate Cos θ *and error.*

21. Determine the value of the χ2 criterion for a sample of 40 measurements x1, x2,... x40 of the length of the trajectory x of a bullet leaving a gun (the results are shown in the table).

731	772	771	681	722	688	653	757	733	742
739	780	709	679	760	748	672	687	766	645
678	748	689	810	805	778	764	753	709	675
698	770	754	830	725	710	738	638	787	712

22. Calculate the average value and standard deviation of the results of ten measurements of one of the indicators characterizing paper quality (for example, paper smoothness): 86, 85, 84, 89, 86, 88, 88, 85, 83, 85.

23. Calculate the confidence interval in the case when the experimenter wants to check the law of conservation of energy for a certain nuclear reaction. For this purpose, he conducts an experiment and obtains the results of the initial and final energy, respectively, Ep=75 $\pm$ *3 MeV and Eq=60* $\pm$ *9 MeV, where the standard deviations of the results are given as errors.*

Is this difference significant (at the 5% level)? It is necessary to give a reasoned answer to the question.

Working program of the academic discipline (syllabus):

Compiled*associate professor, Ph.D., Ploskonos V.G.*

Approved*department ___E and TRP___ (protocol No. 14 dated 08.06.2022)*

Agreed*by the IHF Methodical Commission (protocol No. 10 dated 06.24.2022)*