[BMF14] Measuring transducers and sensors

Syllabus of the academic discipline (Syllabus)

Academic discipline requirements

Level of higher education	First (bachelor's)
Discipline	12 - Information Technology
Specialty	122 - Computer Science
Educational program	All EPs
Discipline status	Selective (F-catalog)
Form of obtaining higher education	Full-time
Year of training, semester	Available for selection starting from the 3rd year, spring semester
Scope of the discipline	120 hours, 4 credits. (Lecture 28 hours, Practical 26 hours, Lab. hours, SRS. 66 hours)
Semester control/control measures	Test
Class schedule	https://schedule.kpi.ua
Language of instruction	Ukrainian / English
Information about the course leader/teachers	Lecturer: A. G. Dubko, Practitioner: A. G. Dubko, SRS.: A. G. Dubko
Course placement	Sikorsky Platform - course "Measurement transducers and sensors"

Academic discipline program

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

The academic discipline "Measurement Converters and Sensors" studies the principles of constructing medical measurement converters and sensors to solve problems related to the development and maintenance of biological and medical devices and systems.

The main goal of the academic discipline "Measurement Converters and Sensors" is to form in students a systematic understanding of measurement converters for capturing medical and biological information, to study the physical principles of operation of these converters, their designs, metrological characteristics and features of their application in biomedical devices.

The objectives of studying the academic discipline are:

- mastering the general principles of using regulatory legal acts and methodological foundations of metrological measurements;
- analyzing the current state of measuring transducers and sensors when conducting biomedical measurements;
- mastering knowledge of measuring instruments and methods, types of standards, calibration and verification of measuring instruments;
- mastering the procedure and procedure for ensuring the unity of measurements;
- mastering knowledge of methods for reducing measurement errors.
- mastering knowledge of interference and methods for combating them.

General competencies (OP put into effect by the Rector's Order NON/89/2021 dated April 19, 2021):

GC 1 Ability to apply knowledge in practical situations.

GC 2 Knowledge and understanding of the subject area and understanding of professional activity.

GC 3 Ability to communicate in the state language both orally and in writing.

GC 6- Ability to search, process and analyze information from various sources.

GC 9 Ability to communicate with representatives of other professional groups of different levels (with experts from other fields of knowledge/types of economic activity).

Special (professional) competencies (OP put into effect by the Rector's Order NON/89/2021 dated April 19, 2021):

FC2- Ability to provide engineering and technical expertise in the planning, development, evaluation and specification of medical equipment.

FC6- Ability to effectively use tools and methods for analysis, design, calculation and testing in the development of biomedical products and services.

FC13- Ability to ensure and monitor compliance with safety and biomedical ethics when working with medical equipment.

The program learning outcomes after studying the discipline "Measurement Converters and Sensors" are (the OP was put into effect by the Order of the Rector NON/89/2021 dated April 19, 2021):

PRN 3 Knowledge of design tools for devices, instruments and systems for medical and biological purposes.

PRN 4 Knowledge of design methods for digital and microprocessor systems for medical purposes.

PRN 7 Understanding of scientific and technical principles that form the basis of the latest achievements in the field of biomedical engineering.

PRN 18 Using practical methods of organization to solve engineering and scientific and practical problems of various levels of complexity.

PRN 24 Apply knowledge of the basics of mathematics, physics and biophysics, bioengineering, chemistry, engineering graphics, mechanics, resistance and strength of materials, properties of gases and liquids, electronics, computer science, acquisition and analysis of signals and images, automatic control, systems analysis and decision-making methods at the level necessary for solving biomedical engineering problems.

PRN 31 Understanding of theoretical and practical approaches to the creation and management of medical equipment and medical technology.

PRN 36 Analysis of signals transmitted from organs to devices, and obtaining and processing diagnostic information.

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of study according to the relevant educational program)

The educational discipline "Measuring Converters and Sensors" belongs to the cycle of professional training and is interdisciplinary in nature. It integrates, according to its subject, knowledge from other educational disciplines: Electrical Engineering and Electronics; Analog and Digital Circuit Engineering. According to the structural and logical scheme of the specialist training program, the discipline "Measuring Converters and Sensors" is closely related to other disciplines in modern scientific research in the specialty, in particular with the disciplines: Devices for monitoring human physiological parameters; Pre-graduate practice.

3. Content of the academic discipline

The main sections and topics that will be covered during the course:

Section 1. General knowledge of measuring equipment

Topic 1.1. The role and significance of measuring equipment

Topic 1.2. Basic concepts and definitions

Topic 1.3. Physical quantities. Fundamentals of metrology and standardization

Topic 1.4. Types and methods of measurements

Topic 1.5. Classification and characteristics of measuring instruments

Topic 1.6. Structures of measuring instruments

Section 2. Classification of measurement errors and methods of their normalization, accuracy classes of measuring instruments, normalized metrological characteristics of measuring instruments

Topic 2.1. Classification of measurement errors

Topic 2.2. Normalization of measuring instruments by errors

Topic 2.3. Accuracy classes of measuring instruments

Section 3. Standards, measures of electrical and magnetic quantities

Topic 3.1. Standards

Topic 3.2. Measures of electrical quantities

Chapter 4. Passive measuring transducers of the second kind

Topic 4.1. Shunts

Topic 4.2. Voltage dividers

Topic 4.3. AC measuring transformers

Chapter 5. Active measuring transducers of the second kind

Topic 5.1. Feedback in amplifiers

Topic 5.2. AC amplifiers

Topic 5.3. DC amplifiers

Section 6. Measuring transducers of the first kind

Topic 6.1. Parametric measuring transducers

Topic 6.2. Generator measuring transducers

Chapter 7. Analog-to-digital and digital-to-analog converters

Topic 7.1. Basic concepts and definitions

Topic 7.2 Principles of analog-to-digital conversion

Topic 7.3. Digital-to-analog converters

Section 8. Methods for reducing measurement errors

Topic 8.1. Negative feedback method

Topic 8.2. Auxiliary measurement method

Topic 8.3 Iterative methods

Topic 8.4 Methods of sample measures

Topic 8.5. Test methods

Section 9. Interference. Methods of combating interference

Topic 9.1. Types of interference, assessment of interference immunity

Topic 9.2. Combating general interference

4. Educational materials and resources

Basic literature:

1. Introduction to Sensors, Instrumentation, and Measurement. Brian D. Storey. Olin College, 2018. – 112p.
2. Jacob Fraden. Handbook of Modern Sensors. Physics, Designs, and Applications. Fourth Edition. Springer ScienceþBusiness Media, 2010. – 663 p.
3. Biomedical Sensors and Instruments. Tatsuo Togawa, Toshiyo Tamura, P. Ake Oberg. Taylor and Francis Group, LLC 2011. - 398p.
4. De Silva, Clarence W. Sensors and actuators : control system instrumentation. Taylor & Francis Group, 2007. – 673 p.
5. Nathan Ida. Sensors, Actuators, and Their Interfaces. A multidisciplinary introduction 2nd Edition. The Institution of Engineering and Technology, 2020. – 899 p.

Additional literature:

1. Medical Devices and Human Engineering. Edited by: Joseph D. Bronzino, Donald R. Peterson. © Taylor & Francis Group, 2015. 858 p.
2. Medical Device Design. Innovation from Concept to Market. First edition. Peter J. Ogrodnik. Academic Press is an imprint of Elsevier, 2013. Kidlington, Oxford. 275 p.
3. ENGINEERING METROLOGY AND MEASUREMENTS. N.V. RAGHAVENDRA, L. RISHNAMURTHY. Oxford University Press, 2013. – 531 p.
4. JOSHUA E. SEGEL. PIEZOELECTRIC ACTUATORS. Nova Science Publishers, Incorporated, 2011. – 144 p.

Educational content

5. Methodology for mastering the academic discipline (educational component)

№	*Topic*	*Program learning outcomes*	*Main tasks*	
			Control measure	*Deadline*
1.	*Physical quantities. Fundamentals of metrology and standardization*	*PRN 24* *PRN 31*	*Practical work 1*	*1-2 week*
2.	*Accuracy classes of measuring instruments*	*PRN 18* *PRN 31*	*Practical work 2*	*3-4 week*
3.	*Measures of electrical quantities*	*PRN 4* *PRN 31*	*Practical work 3*	*5-6 week*
4.	*Shunts*	*PRN 24* *PRN 36*	*Practical work 4*	*7-8 week*
5.	*AC instrument transformers*	*PRN 18*	*Practical work 5*	*9-10 week*

№	Topic	Program learning outcomes	Main tasks	
			Control measure	Deadline
		PRN 4 PRN 36		
6.	Feedback in amplifiers	PRN 31	Practical work 6	11 week
7.	Generator measuring transducers	PRN 24 PRN 31	Practical work 7	12-13 week
8.	Modular test work	PRN 7	Writing MTW	14 week
9.	Homework test	PRN 18	Designing and sending work	15-16 week

6. Student's independent work

One of the main types of semester control during the mastering of the academic discipline "Measurement Converters and Sensors" is the performance of homework. Homework is performed in accordance with the requirements, within the time specified by the teacher.

The main goal of homework is to solve a practical problem using theoretical material learned in lectures and independently, and practical skills obtained in practical classes. A student can write a homework test only on a topic agreed with the teacher.

Approximate topic of the homework test:

№1	Physical phenomena and energy transformations used in sensors
№2	Measurement and conversion of physical quantities
№3	Optoelectronic sensors
№4	Strain gauges.
№5	Electromagnetic sensors
№6	Temperature sensors. Thermistors
№7	Piezoelectric sensors
№8	Multi-sensor electronic odor and taste detectors
№9	Trends in the development of sensors of physical quantities and measurement methods in biometrics

The title page of the homework test should have the following content: name of the university; name of the faculty; name of the department; name of the specialty, name of the educational and professional program,

name of the academic discipline; topic of the homework test; student's last name and first name, course, academic group number, year.

The title page is followed by a detailed plan (contents) of the homework test, which should include the introduction, sections of the main content (main topics studied), their subdivisions (if necessary), conclusion, and a list of sources used. The page numbers of the beginning of each question are indicated on the right in the table of contents. Each section begins on a new page.

The total volume of the homework test, depending on the selected topic, can vary from 25 to 40 pages of the main text (upon agreement with the teacher). The volume of the homework test is determined by the student's ability to concisely and at the same time comprehensively explain the results obtained.

Mandatory requirement: clear reference to sources of information. All figures, facts, opinions of scientists, quotes, formulas must have references in the form of [2, p. 54] (the first digit means the number of the source in the list of literature given at the end of the creative work, and the second digit is the page number in this source). It is advisable to use tables, diagrams, graphs, charts, etc. The list of sources used (at least 10 sources) is drawn up in accordance with current rules. If the information is taken from the Internet, it is necessary, as for ordinary literature, to indicate the author, the title of the article, and then give the address of the site on the Internet.

Homework is evaluated according to the following criteria: logicality of the plan; completeness and depth of disclosure of the topic; reliability of the data obtained; reflection of practical materials and calculation results; correctness of the formulation of the conclusions of the obtained results and conclusions; design; substantiation of the student's own opinion on this issue in the form of a conclusion.

The deadline for submitting homework for review is the 16th week of study.

Homework is not checked for plagiarism, but must meet the requirements of academic integrity. If academic dishonesty is detected, the work is canceled and not checked.

Policy and control

7. Academic discipline policy (educational component)

Attendance at classes

Attendance at lectures is not mandatory. Attendance at practical classes is desirable, as they include writing quick tests/tests, and explaining the execution of subsequent practical assignments and their submission.

The assessment system is focused on obtaining points for student activity, as well as completing tasks that can develop practical skills.

Missed tests

Missed tests (practical work defense) must be made up in the following classes, provided that the task scheduled for the current class or consultations is completed.

Missed writing of modular tests and express tests are not made up.

Homework submitted for review after the deadline is evaluated with a reduced number of weighted points.

Violation of task deadlines and incentive points

Incentive points		*Penalty points **	
Criterion	*Weighted score*	*Criterion*	*Weighted score*
Improving practical work	*1 point* *(for each practical work)*	*Untimely completion and defense of practical work*	*From -0.5 points to -3 points* *(depends on the deadline)*
Taking distance courses on topics agreed upon with the teacher	*5 points*	*Untimely execution and submission of the HW*	*From -2 points to -10 points (depends on the submission deadline)*
Preparation of a scientific paper for participation in a student scientific paper competition	*10 points*		
Writing theses, articles, participation in international, all-Ukrainian and/or other events or competitions on the topic of the academic discipline	*5 points*		

** If the control measure was missed for a good reason (illness confirmed by a certificate of the established form) - no penalty points are accrued.*

Academic Integrity

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

Standards of Ethical Conduct

The standards of ethical conduct of students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More information: https://kpi.ua/code.

Procedure for appealing the results of control measures

Students have the opportunity to raise any issue related to the control measures procedure and expect that it will be considered in accordance with the pre-defined procedures.

A student has the right to appeal the results of the control measure in accordance with the approved Regulation On Appeals at Igor Sikorsky Kyiv Polytechnic Institute (approved by order No. HOH/128/2021 dated 05/20/2021) - https://osvita.kpi.ua/index.php/node/182

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Distance learning

Distance learning takes place through the Sikorsky Distance Learning Platform.

Distance learning through additional online courses on a specific topic is allowed subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material through such courses is allowed, but students must complete all the tasks provided for in the academic discipline.

The list of courses is offered by the teacher after the students express their desire (since the bank of available courses is updated almost every month).

The student provides a document confirming the completion of the distance course (in case of completing the full course) or provides completed practical tasks from the distance course and, subject to passing an oral interview with the teacher on the topics covered, can receive grades for the control measures provided for the studied topics (express control / test tasks, practical work).

Practical work, as well as homework, is carried out during independent work of students in remote mode (with the possibility of consulting with the teacher via email, social networks).

Studying in a foreign language

Study in English is carried out only for foreign students.

At the request of students, it is allowed to study the material using English-language online courses on topics that correspond to the topics of specific classes.

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

Evaluation system (current control):

№	*Control measure*	*%*	*Weighted point*	*Number*	*Total*
1.	*Express control work / test tasks*	*21*	*1,5*	*14*	*21*
2.	*Completion and defense of practical work*	*21*	*3*	*7*	*21*
3.	*Modular test work*	*8*	*8*	*1*	*8*
4.	*Homework test*	*10*	*10*	*1*	*10*
5.	*Test*	*40*	*40*	*1*	*40*
	Total				*100*

Calendar control (CC) - is carried out twice a semester as a monitoring of the current status of implementation of syllabus requirements.

The purpose of calendar control is to improve the quality of student learning and monitor the implementation of the educational process schedule by students.

Criterion			*First C C*	*Second C C*
Calendar control period			*8th week*	*Week 14*
Conditions for obtaining a positive result from calendar control	*Current rating*		*≥ 12 points*	*≥ 24 points*
	Performing practical work	*PW №№1-4*	*+*	*+*
		PW №№5-7	*-*	*+*
	Express control work / test tasks	*Minimum of 4 of any lectures*	*+*	*-*
		Minimum of 10 any lectures	*-*	*+*
	Modular test work	*Estimated MTW*	*-*	*+*
	Homework test	*Estimated HT*	*-*	*-*

If academic dishonesty is detected during studies, the test will not be counted.

Semester certification of students

	Mandatory condition for admission to the test	*Criterion*
1	*Current rating*	*RD ≥ 30*
2	*Receiving a positive grade for completed homework*	*More than 6 points*
3	*All practical work is protected*	*More than 6 points*
4	*Writing at least 6 express control papers / test tasks*	*More than 6 points*

The results are announced to each student individually in person at the test event or remotely (by e-mail). They are also recorded in the "Electronic Campus" system.

Mandatory conditions for admission to the test:

1. Activity in practical classes.

2. Positive result of the first certification and the second certification.

3. Attendance at lectures.

The test is conducted orally.

Table of correspondence of rating scores to university scale grades

Number of points	**Rating**
100-95	Perfectly
94-85	Very good
84-75	Good
74-65	Satisfactorily
64-60	Enough
Less than 60	Unsatisfactorily
Admission conditions not met	Not allowed

9. Additional information on the discipline (educational component)

A list of questions for preparing for the module test, as well as for preparing for the exam, is provided in Appendix 1.

Distance learning through additional online courses on a specific topic is permitted subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material through such courses is permitted, but students must complete all tasks provided for in the academic discipline.

The list of courses is offered by the teacher after the students express their desire (since the bank of available courses is updated almost every month).

The student provides a document confirming the completion of the distance course (in case of completing the full course) or provides completed practical tasks from the distance course and, subject to passing an oral interview with the teacher on the topics covered, can receive grades for the control measures provided for the studied topics (express control / test tasks, practical work).

Description of the material, technical and information support of the discipline

Educational and working program of the discipline, RSO, textbook (electronic edition), syllabus, online course in Moodle, practical classes, laboratory practicum URL: https://do.ipo.kpi.ua

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The working program of the academic discipline (syllabus):
Compiled by Dubko A. G.;

Approved by the BMI Department (protocol No. 15 dated 24/06/2025)
Approved by the methodological committee of the faculty/NII (protocol No. 12 dated 30/06/2025)