National Technical University of Ukraine
«IGOR SIKORSKY
KYIV POLYTECHNIC INSTITUTE

Department of Biomedical Engineering

BIOMEDICAL SENSORY SYSTEMS

Syllabus

Requisites of the discipline	
Level of high education	***First (bachelor's)***
Branch of knowledge	*16 Chemical and bioengineering*
Specialty	*163 Biomedical Engineering*
Educational program	*Medical engineering*
Status of the discipline	*Selective*
Learning form	*full-time / day / mixed / remote*
Semester	*3rd year, spring semester*
Course scope	*4 credits / 120 hours*
Semester control / control measures	*Test, modular control work*
Schedule	*According to the schedule on the website http://rozklad.kpi.ua/*
Language	*English*
Information about course supervisor and lecturers	***Lecturer:*** *Associate Professor of Biomedical Engineering, PhD of Technical Sciences, Dubko Andrii Grigorovich,* *intellect.kpi.ua/profile/dag5;* *http://www.nas.gov.ua/UA/PersonalSite/Pages/default.aspx?PersonID=0000016737* *http://orcid.org/0000-0001-6070-3945* *https://www.scopus.com/authid/detail.uri?authorId=55226164600.* ***Practical:*** *Associate Professor of Biomedical Engineering, PhD of Technical Sciences, Dubko Andrii Grigorovich,* *intellect.kpi.ua/profile/dag5;* *http://www.nas.gov.ua/UA/PersonalSite/Pages/default.aspx?PersonID=0000016737* *http://orcid.org/0000-0001-6070-3945* *https://www.scopus.com/authid/detail.uri?authorId=55226164600.*
Course placement	***Sikorsky Platform - course*** *" Biomedical sensory systems "*

Curriculum of the discipline

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

The discipline "Biomedical sensor systems" studies the principles of construction of biomedical sensor systems for medical purposes to solve problems related to the development and maintenance of medical devices and systems.

The main purpose of the discipline "Biomedical sensory systems" is to form in students a systematic understanding of sensory systems of medical and biological information, study the physical principles of these systems, their designs, metrological characteristics and features of their use in biomedical devices.

The objectives of the discipline are:

- use of normative legal acts and methodological bases of metrological measurements;

- analysis of the current state of biomedical sensory systems;

- mastering knowledge of means and methods of measurement, verification of measuring instruments;

- choice of algorithms and means of information processing;

- mastering knowledge of microprocessors as functional devices of controllers that provide effective automatic execution of digital information processing operations in accordance with a given algorithm;

- mastering knowledge of data interfaces.

General competencies *(OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):*

***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 *(OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):*

PC 1 - Ability to use engineering software packages for research, analysis, processing and presentation of results, as well as for automated design of medical devices and systems.

PC 4- Ability to provide technical and functional characteristics of systems and tools used in medicine and biology (in prevention, diagnosis, treatment and rehabilitation).

PC 5- Ability to apply physical, chemical, biological and mathematical methods in the analysis, modeling of the functioning of living organisms and biotechnical systems.

PC 10- Ability to apply the principles of construction of modern automated control systems for the production of medical devices, their technical, algorithmic, informational and software for solving professional problems.

The program learning outcomes after studying the discipline " Engineering and computer graphics" are (OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):

PLO 1 - Understanding of fundamental-applied, medical-physical and bioengineering bases of technologies and equipment for research of processes of a human body.

PLO 4 Knowledge of methods of designing digital and microprocessor systems for medical purposes.

PLO 9 - Application of principles of construction of automatic control systems and properties of their elements.

PLO 11 - Knowledge of the basic operating conditions of diagnostic and therapeutic systems, medical complexes and systems.

PLO 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, obtaining and analyzing signals and images,

automatic control, systems analysis and decision making methods at the level required to solve the problems of biomedical engineering.

PLO 28 - Use of databases, mathematical and software for data processing and computer modeling of biotechnical systems.

PLO 33 Planning, organization and control of medical-technical and bioengineering systems and processes.

PLO 36 Analysis of signals transmitted from organs to devices, and receipt and processing of diagnostic information.

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

The discipline "Biomedical sensory systems" belongs to the cycle of professional training and has an interdisciplinary nature. It integrates according to its subject knowledge from other disciplines: Electrical Engineering and Electronics; Analog and digital circuitry. According to the structural and logical scheme of the training program, the discipline "Biomedical sensory systems" is closely related to other disciplines in modern research in the specialty, in particular with the disciplines: Devices for monitoring physiological parameters of man; Pre-diploma practice.

3.The content of the discipline

The main sections and topics that will be considered in the process of studying the course:

Section 1. Basic concepts of information-measuring complexes and systems.

Topic 1.1. The main definitions, scope and features of information
measuring complexes and information-measuring systems.
Topic 1.2. Classification of information and measuring systems.
Topic 1.3. The main structural elements of information and measuring systems.
Topic 1.4. Basic requirements for rules and methods of testing information and measuring systems.

Section 2. Information characteristics of information-measuring complexes and information-measuring systems.

Topic 2.1. The amount of information.
Topic 2.2. The flow of information.
Topic 2.3. Information channel bandwidth.
Topic 2.4. Structure and algorithms of information-measuring complexes and information-measuring systems.

Section 3. The structure of the information-measuring complex.

Topic 3.1. The main types of structures of information and measuring complexes.
Topic 3.2. Characteristics of information-measuring complexes.
Topic 3.3. Principles of formation of complexes of receiving information.

Section 4. Microprocessor controllers and microcontrollers - the main part of information and measuring systems

Topic 4.1. Classification of controllers
Topic 4.2. Modular controllers
Topic 4.3. Frame controllers

Topic 4.4. Virtual structure of controllers.

Section 5. Analog-to-digital converters and their characteristics.

Topic 5.1. Areas of application of analog-to-digital converters.

Topic 5.2. Analog-to-digital converters for data collection and processing systems.

Topic 5.3. Analog-to-digital converters for precision systems and measuring equipment.

Section 6. The concept of sensors and features of their operation.

Topic 6.1. Physical phenomena and energy transformations used in sensors.

Topic 6.2. Varieties and features of physical quantities.

Topic 6.3. Measurement and conversion of physical quantities.

Section 7. Sensory information in the coordination system of living organisms

Topic 7.1. Structure and functions of receptors.

Topic 7.2. Optoelectronic sensors

Topic 7.3. Strain gauges.

Topic 7.4. Electromagnetic sensors.

Topic 7.5. Temperature sensors. Thermistors.

Topic 7.6. Galvanomagnetic sensors. Hall sensor.

Topic 7.7. Ultra-high frequency electromagnetic sensors.

Topic 7.8. Electronic control sensors.

Section 8. Nanosensory systems

Topic 8.1. Sensors based on optical waveguides with photonic crystal structure.

Topic 8.2. Sensors based on carbon nanotubes.

Topic 8.3. Nanobiosensors.

Topic 8.4. Multisensory electronic odor and taste detectors.

Topic 8.5. Trends in the development of sensors of physical quantities and methods of measurement in biometrics.

Section 9. Interfaces.

Topic 9.1. Classification of interfaces.

Topic 9.2 Data interfaces.

Section 10. Local networks of information-measuring complexes and information-measuring systems.

Topic 10.1. History of computer communication development.

Topic 10.2. Local area networks.

Topic 10.3 Types of communication lines of local networks.

4. Training materials and resources

Basic literature, which should be used to master the discipline, is developed independently to prepare forpractical classes and in the context of distance learning. It is suggested to use additional literature and Internet resources to perform modular tests, prepare reports, presentations, write essays based on the results of independent work.

1. *Introduction to Sensors, Instrumentation, and Measurement. Brian D. Storey. Olin College. – 2018. – 112p.*
2. *Biomedical Sensors and Instruments. Tatsuo Togawa, Toshiyo Tamura, P. Ake Oberg. © 2011 by Taylor and Francis Group, LLC- 398p.*
3. *Medical Devices and Human Engineering. Edited by: Joseph D. Bronzino, Donald R. Peterson. © Taylor & Francis Group - 2015. 858 p.*
4. *Jacob Fraden. Handbook of Modern Sensors. Physics, Designs, and Applications. Fourth Edition. Springer SciencebBusiness Media, - 2010. – 663 p.*
5. *Medical Devices and Systems .The Electrical Engineering Handbook Series. Edited by Joseph D. Bronzino. Trinity College Hartford, Connecticut, U.S.A. – 2006. – 1404p.*
6. *Modern Sensors Handbook. Pavel Ripka, Alois Tipek. by ISTE, - 2007. - 515 p.*
7. *Measurement and Instrumentation Principles. Alan S. Morris. Third edition. Butterworth-Heinemann 2001. –475 p.*

Additional literature:

1. *Койфман О.О. Конспект лекцій з дисципліни «Сенсори для біомедицини» для студентів за напрямом підготовки 163 «Біомедична інженерія». ДВНЗ «Приазовський державний технічний. університет». Затверджена на засіданні кафедри «Біомедична інженерія», протокол 24.06.2019 року № 21. – 78 с.*
2. *K. Venkata Reddy. Textbook of Engineering Drawing. Second Edition. BS Publications 2008. -377p.*
3. *Основи реєстрації та аналізу біосигналів. Навчальний посібник / О.Г. Аврунін, В.В. Семенець, В.Г. Абакумов, З.Ю. Готра, С.М. Злепко, А.В. Кіпенський, С.В. Павлов. – Харків: ХНУРЕ, 2019. – 400 с.*

Educational content

5. Methods of mastering the discipline (educational component)

№ s/n	Subject	Program learning outcomes	The main tasks	
			Control measure	Deadline
1.	The main structural elements of information and measuring systems.	PLO 4 PLO 11 PLO 28	Practical work 1	1-2nd week
2.	Structure and algorithms of information-measuring complexes and information-measuring systems.	PLO 9 PLO 33	Practical work 2	3-4th week
3.	Modular controllers	PLO 24	Practical work 3	5-6th week

№ s/n	Subject	Program learning outcomes	The main tasks	
			Control measure	Deadline
		PLO 36		
4.	Analog-to-digital converters for data collection and processing systems.	PLO 24 PLO 36	Practical work 4	7-8th week
5.	Strain gauges	PLO 9 PLO 24 PLO 36	Practical work 5	9-10th week
6.	Data interfaces.	PLO 24 PLO 36	Practical work 6	11th week
7.	Types of communication lines of local networks.	PLO 24 PLO 36	Practical work 7	12-13th week
8.	Modular control work	PLO 1 PLO 24	Writing a modular test	14th week
9.	Home control work	PLO 24	Registration and submission of work	15-16th week

6. Independent student work

One of the main types of semester control during the mastering of the discipline "Biomedical sensor systems" is the performance of homework. Homework is performed in accordance with the requirements, within the period specified by the teacher.

The main purpose of homework is to solve a practical problem using the material learned in lectures and independently, and practical skills acquired in practical classes. The student can write homework only on the subject agreed with the teacher.

Approximate topics:

№1 Information and measuring complexes and systems.
№2 Physical phenomena and energy transformations that used in sensors
№3 Measurement and conversion of physical quantities.
№4 Microcontrollers are the main part of information and measuring systems
№5 Analog-to-digital converters.
№6 Strain gauges.
№7 Piezoelectric sensors.
№8 Electromagnetic sensors.
№9 Optoelectronic sensors.
№10 Smell and taste sensors.

The title page of the homework should have the following content: the name of the university; name of the faculty; name of department; name of specialty, name of educational-professional program, name of academic discipline; topic of home control work; surname and name of the student, course, number of the academic group, year.

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

The total amount of homework depending on the chosen topic can vary from 25 to 40 pages of the

main text (in consultation with the teacher). The amount of homework is determined by the student's ability to briefly and comprehensively explain the results.

Mandatory requirement: clear reference to sources of information. All figures, facts, opinions of scientists, quotations, formulas must have a reference in the form [2, p. 54] (the first digit means the number of the source in the list of references given at the end of the creative work, and the second digit - the page number in this source). It is desirable to use tables, diagrams, graphs, charts, etc. The list of used sources (not less than 10 sources) is made out according to operating rules. If the information is taken from the Internet, you need, as for ordinary literature, to indicate the author, the title of the article, and then provide the address of the site on the Internet.

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

Deadline for submitting homework for review: 16th week of study.

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

Policy and control

7. Policy of academic discipline (educational component)

Attending classes

Attendance at lectures is optional. Attending practical classes is desirable, as they are used to write express tests / tests, as well as to defend practical work.

The grading system is focused on obtaining points for student activity, as well as performing tasks that are able to develop practical skills and abilities.

Control measures missed

Missed control measures (defense of practical work) must be practiced in the next classes, provided that the task is scheduled for the current lesson, or in consultations.

Omissions of writing a module test and express test are not fulfilled.

Home control work, which is submitted for inspection in violation of the deadline is evaluated with a decrease in the number of weight points.

Violation of deadlines and incentive points

Encouragement points		*Penalty points **	
Criterion	*Weight points*	*Criterion*	*Weight points*
Improving practical work	*1 points (for each practical work)*	*Untimely implementation and test of practical work*	*From -0.5 points to -5 points (depending on the delivery date)*
Passing distance courses on topics that are agreed with teachers	*5 points*	*Untimely execution and test of calculation and home work*	*From -2 points to -20 points (depending on the construction period)*

Registration of scientific work for participation in the competition of student scientific works	*10 points*		
Writing abstracts, articles, participation in international, national and / or other events or competitions on the subject of the discipline	*5 points*		

** if the control measure was missed for a good reason (illness, which is confirmed by a certificate of the established sample) - penalty points are not 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". Read more: https://kpi.ua/code.

Norms of ethical behavior

Normative principles of behavior of students and employees, defined in sections 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code.

Procedure for appealing the results of control measures

Students have the opportunity to raise any issue related to the control procedure and expect it to be addressed according to predefined procedures.

The student has the right to appeal the results of the control measure according to the approved provision on appeals in the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (approved by the order №NON/128/2021 from 20.05.2021)- https://osvita.kpi.ua/index.php/node/182

Inclusive education

The discipline "Biomedical Sensory Systems" can be taught to most students with special educational needs, except for students with severe visual impairments who do not allow to perform tasks using personal computers, laptops and / or other technical means.

Distance learning

Distance learning takes place through the Sikorsky Distance learning Platform «Sikorsky».

Distance learning through additional online courses on certain topics 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 with such courses is allowed, but students must complete all the tasks provided in the discipline.

The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).

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

Performance of practical works, and also performance of settlement and graphic work, is carried out during independent work of students in a remote mode (with a possibility of consultation with the teacher through e-mail, social networks).

Learning a foreign language

Teaching in English is carried out only for foreign students.

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

8. Monitor and evaluate the system of evaluation of learning outcomes (Rating System of Evaluation)

Evaluation system (current control):

№ s/n	Control measure	%	Weight points	Number	Total
1.	Express control works / test tasks	21	1,5	14	21
2.	Execution and protection of practical works	21	3	7	21
3.	Modular control work	8	8	1	8
4.	Home control work	10	10	1	10
5.	Test	40	40	1	40
				Total	100

Calendar control *(CC) - is performed twice a semester as monitoring of the current state of compliance with syllabus requirements.*

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

Criterion			The first CC	The second CC
Deadline of calendar controls			8th week	14th week
Conditions for obtaining a positive result from the calendar control	Current rating		≥ 24 points	≥ 40points
	Execution practical work	PW №№1-4	+	+
		PW №№5-7	-	+
	Express control works / test tasks	At least 4 of any lectures	+	-
		At least 10 of any lectures	-	+
	Modular control work	Estimated MCW	-	+
	Home control work	Evaluated HCW	-	-

In case of detection of academic poor quality during training - the control measure is not credited.

Semester certification of students

Mandatory condition for admission to the exam		***Критерій***
1	Current rating	RD ≥ 30
2	Obtaining a positive assessment for the performed calculation and graphic work	More than 6 points
3	All practical works are tested	More than 6 points
4	Writing at least 6 express tests / tests	More than 6 points

The results are announced to each student separately in the presence or remotely (by e-mail). Also recorded in the system "Electronic Campus".

Mandatory conditions for admission to the exam:
1. Activity in practical classes.
2. Positive result of the first attestation and the second attestation.
3. Attending lectures.

Table of translation of rating points to grades on a university scale:

Number points	*Assessment on the university scale*
100-95	*Perfectly / Відмінно*
94-85	*Very good / Дуже добре*
84-75	*Good / Добре*
74-65	*Satisfactorily / Задовільно*
64-60	*Enough / Достатньо*
Less 60	*Unsatisfactorily / Незадовільно*
Admission conditions are not met	*Not allowed / Не допущено*

The test is held orally.

9. Additional information on the discipline (educational component)

The list of questions for preparation for modular control work, and also for preparation for examination is given in appendix 1.

Distance learning through additional online courses on certain topics 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 with such courses is allowed, but students must complete all the tasks provided in the discipline.

The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).

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

Work program of the discipline (syllabus):

Compiled by *Associate Professor of Biomedical Engineering, PhD of Technical Sciences, Dubko Andrii Grigorovich.*

Approved by *the Department of Biomedical Engineering (protocol № ___ to _____)*

Approved by *the Methodical Commission of the Faculty of Biomedical Engineering(protocol № __ to _____)*

Appendix 1 to the syllabus of the discipline

«Biomedical sensory systems»

The list of questions for preparation for modular control work,

as well as to prepare for the test

1. List the main regulations necessary for the development and operation of biomedical sensor systems.
2. Define what is the scope and characteristics of information-measuring systems and information-measuring systems?
3. Classification of information and measuring systems
4. The main structural elements of information and measurement systems.
5. Basic requirements to the rules and methods of testing information and measuring systems.
6. Define what is the unity of measurements and metrology?
7. What does the physical quantity reflect?
8. Write down the basic equation of measurement.
9. List the basic physical quantities in the International System of Units SI.
10. Define what is the amount of information.
11. Define what is the flow of information ..
12. Define what is the bandwidth of the information channel.
13. Structure and algorithms of information-measuring complexes and information-measuring systems.
14. The main types of structures of information and measuring systems.
15.. Characteristics of information-measuring complexes.
16. Principles of formation of complexes of receiving information.
17. Define what is a controller, as the central part of the information-measuring complex that transmits, processes and stores information.
18. Classification of controllers
19. Modular controllers
20. Frame controllers
21. Virtual structure of controllers.
22. Areas of application of analog-to-digital converters
23. Analog-to-digital converters for data collection and processing systems.
24. Analog-to-digital converters for precision systems and measuring equipment.
25. The structure and function of receptors.
26. Optoelectronic sensors
27. Strain gauges.
28. Electromagnetic sensors.
29. Temperature sensors. Thermistors.
30. Galvanomagnetic sensors. Hall sensor.
31. Ultra-high frequency electromagnetic sensors.
32. Sensor sensors for electronic control.
33. Sensors based on optical waveguides with photonic crystal structure.
34. Sensors based on carbon nanotubes.
35. Nanobiosensors.
36. Multisensor electronic odor and taste detectors.
37. Trends in the development of sensors of physical quantities and methods of measurement in biometrics.
38. Classification of interfaces.

39. Data interfaces.
40. History of computer communication.
41. Local area networks.
42. Types of communication lines of local networks.