Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department
Biomedical Engineering

INFORMATION SUPPORT OF DIAGNOSTIC AND THERAPEUTIC PROCESSES OF PATIENTS WITH LOST LIMBS

Work program of the academic discipline (Syllabus)

Details of the discipline	
Higher education level	***First (bachelor's)***
Field of Knowledge	*16 Chemical and Bioengineering*
Specialty	*163 Biomedical Engineering*
Educational program	*Medical Engineering*
Discipline status	*Selective*
Form of study	*full-time (full-time)/ mixed/ distance*
Year of preparation, semester	*4th year, spring semester*
Scope of discipline	*4 ECTS credits / 120 hours*
Semester control / control measures	*Credit, MKR, Abstract*
Class schedule	*According to the schedule on the website http://roz.kpi.ua/*
Language of instruction	*English*
Information about the course leader / teachers	***Lecturer:*** *Doctor of Technical Sciences, Associate Professor, Head Department of BME Shlykov Vladyslav Valentynovych, e-mail: v.shlykov@kpi.ua, Telegram: https://t.me/vshlykov, Zoom: 759 0245 5108, code 202202* ***Practical:*** *Assistant of the Department of BME Tsarenko Mykola Andriyovych, e-mail: n.tsarenko94@gmail.com, Telegram: https://t.me/myk0la_st*
Course placement	*Sikorsky Platform*

Distribution of hours

Semester	Lectures	Practical	Laboratory	Independent Work
spring semester	*30*	*30*	*0*	*60*

Program of the discipline

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

The main goal of the educational component is to form students' understanding of the principles, skills and practical skills of using information technologies in the diagnosis and treatment of patients with lost limbs.

During the study of the educational component, research skills will be developed to determine appropriate intervention methods during a particular clinical case, while understanding the complex

interaction between social, economic and environmental impacts. With an understanding of the measurement and analysis of some parameters, it is possible to learn to interpret these results to make decisions to achieve a positive effect of diagnosis and treatment. Based on the obtained elements of evidence-based medicine, plan diagnostic and therapeutic measures for patients with lost limbs.

The study of the educational component strengthens the following special (professional) competencies:

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

PC 11 *- Ability to develop, plan, and conduct experiments using specified technical and biomedical techniques, applying mathematical methods in the analysis and modeling of the functioning of living organisms, systems, and processes in biology and medicine, computer processing, analysis, and synthesis of the obtained results.*

The study of the educational component enhances the following program learning outcomes*:*

PLO 2 - *Formulate logical conclusions and reasoned recommendations regarding the assessment, operation, and implementation of biotechnical, medical-technical, and bioengineering tools and methods.*

PLO 5 - *Be able to use databases, mathematical and software tools for data processing and computer modeling of biotechnical systems.*

PLO 20 - *Knowledge and application of research methods in biomedical engineering, methods and tools for organizing and processing experimental data, statistical methods for modeling and simulating processes and systems of physical and biological nature, modern programming technologies and supporting tools, methods for designing digital and microprocessor-based medical systems.*

PLO 23 - *Development and implementation of modern diagnostic and therapeutic methods associated with the use of biotechnology, computer, and nanotechnology through the improvement of technical elements of medical devices and systems, as well as medical products, in the process of professional activity.*

Knowledge and skills that a higher education applicant will possess after studying the educational component:

Knowledge:

- *principles of patient-specific prosthetics and implantation;*
- *methods of three-dimensional modeling and reconstruction of anatomical structures based on medical images;*
- *basics of engineering analysis and optimization of biomedical devices; modern technologies for the manufacture of medical devices.*

Skills:

- *analyze medical data and create patient-specific three-dimensional models;*
- *design prostheses, implants and surgical aids taking into account the individual characteristics of patients;*
- *perform engineering analysis and use its results to optimize products;*
- *to apply modern engineering and information approaches to solve applied problems of biomedical engineering.*

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

The educational component "Information Support of Diagnostic and Therapeutic Processes of Patients with Lost Limbs" belongs to the cycle of professional training at the student's choice and has an interdisciplinary character. It integrates knowledge of other educational components in accordance with its subject: Introduction to the specialty, Biomedical devices, devices and complexes, Design of medical information systems, Fundamentals of computer science, Object-oriented programming. According to the structural and logical scheme of the training program of a specialist at the student's choice The educational component "Information support of diagnostic and therapeutic processes of patients with lost limbs" is the basis for the preparation of diploma works in the specialty and in further practical work in the specialty.

3. Content of the discipline

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

Chapter 1. Theoretical Foundations of Patient-Specific Prosthetics and 3D Modeling

1.1. Modern engineering and technological approaches in prosthetics and patient-specific implantation. The concept of "informatization society". Stages of formation.

1.2. Basics of three-dimensional modeling: 3D data formats, methods for converting two-dimensional images into three-dimensional models, and basic principles of building 3D structures.

1.3. Patient-specific 3D modeling and design of prostheses, taking into account technical requirements and principles of design individualization.

1.4. Using medical CT/CBCT images to create patient-specific models. DICOM standard.

Chapter 2. Methods for processing medical images and creating three-dimensional anatomical models

2.1. Analysis and processing of medical images to build three-dimensional anatomical models.

2.2. Medical Imaging Artifacts: Causes, Physical Mechanisms, and Methods to Eliminate Them.

2.3. Creation of three-dimensional models based on CT and CBCT data: segmentation, reconstruction and visualization of anatomical structures.

2.4. Virtual planning of surgical interventions using three-dimensional anatomical models.

Chapter 3. Engineering design and creation of complex 3D models of medical devices

3.1. 3D engineering design methods for additive manufacturing of medical devices.

3.2. Principles of creating complex geometric shapes and functional structures in patient-specific products.

3.3. Design of implants and prostheses taking into account the individual anatomical and biomechanical characteristics of the patient

3.4. Development of patient-specific surgical guides to improve the accuracy and safety of surgical interventions.

Chapter 4. Optimization and engineering analysis of personalized treatment solutions

4.1. Preparation of three-dimensional models for engineering analysis: construction of calculation models, setting material properties and boundary conditions.

4.2. Analysis of the stress-strain state of medical devices and interpretation of calculation results.

4.3. Methods for optimizing personalized design strategies based on three-dimensional modeling.

4.4. Automation and optimization of patient-specific product design processes using algorithmic approaches.

Chapter 5. Innovative Technologies of Additive Manufacturing in Medicine

5.1. Modern technologies of additive manufacturing in medical practice and their clinical application.

5.2. Preparation of digital models for additive manufacturing and organization of the production process.

5.3. Methods of post-processing and quality control of medical devices manufactured using additive technologies.

4. Training materials and resources

Basic literature:

1. *WHO Standard Package for the Evaluation of Prosthetics and Orthotics: A User Guide. – 2023. Access mode: https://resources.relabhs.org/uk/resource/who-standards-for-prosthetics-and-orthotics-assessment-package-user-manual-uk/*
2. *WHO Standards for the Prosthetics and Orthotics Assessment Package: An Assessment Guide. – 2023. Access mode: https://resources.relabhs.org/uk/resource/who-standards-for-prosthetics-and-orthotics-assessment-package-assessment-guide-uk/*
3. *Guide to the Analysis and Use of Routine Health Information Systems: Rehabilitation Module. – 2022. Access mode: https://resources.relabhs.org/uk/resource/guidance-on-the-analysis-and-use-of-routine-health-information-systems-rehabilitation-module-uk/*
4. *Radzishevska E.B., Vysotska O.V. Information Technologies in Medicine. Ehealth / for a row. V. G. Book. – Kharkiv: KhNMU, 2019. – 72 p. (in Russian).*
5. *Physical rehabilitation of veterans. Training materials for rehabilitators working with veterans. – 2022. Access mode: https://ingeniusua.org/fizychna-reabilitatsiya-veteraniv?fbclid=IwAR0MtQtwu7V_yr1MljUHsK1qoz3MHOSPgLesyKOpX90iClOriAja6Ekfk0o*
6. *Протезування та штучні органи: Конспект лекцій: навч. посіб. для студ. спеціальності 163 «Біомедична інженерія» / І. Ю. Худецький, Ю. В. Антонова-Рафі, Г. В. Мельник, Є. В. Сніцар ; КПІ ім. Ігоря Сікорського. – Київ: КПІ ім. Ігоря Сікорського, 2021. – 184 с. – https://ela.kpi.ua/handle/123456789/45797*
7. *3D printing in medicine / Kalaskar, Deepak M., ed. – Woodhead Publishing, 2017. – 422 P. – ISBN 978-0081007174. – https://www.perlego.com/book/3864754/3d-printing-in-medicine-pdf*
8. *Advances in 3D printing & additive manufacturing technologies / D. I. Wimpenny, P. M. Pandey, L. J. Kumar. – Springer, 2017. - ISBN 978-981-10-0811-5. – https://pdf.lib.vntu.edu.ua/books/Springer/2020/2017_Book_AdvancesIn3DPrintingAdditiveMa.pdf*
9. *3D printing and bio-based materials in global health / Bhatia, S. K., Ramadurai K. W. – Springer Briefs in Materials, 2017. – ISBN 978-3-319-58276-4. – https://pdf.lib.vntu.edu.ua/books/Springer/2020/2017_Book_3DPrintingAndBio-BasedMaterial.pdf*
10. *Principles of Regenerative Medicine / Anthony Atala, Robert Lanza, Tony Mikos, Robert Nerem. - Academic Press, 2017. – ISBN: 978-0-128-09880-6. – https://epdf.pub/queue/principles-of-regenerative-medicine-5ea6b5f69db90.html*

Further reading:

1. *Systems and methods of decision support. [Electronic resource] study. Manual. for applicants for a master's degree in the educational programs "System Analysis and Management", "System Analysis of the Financial Market" of specialty 124 "System Analysis" / P.I. Bidyuk, O.L. Tymoshchuk, A.E. Kovalenko; L.O. Korshevnyuk KPI. Igor Sikorsk; Electronic text data (1 file: 3.445 MB). Kyiv: KPI. Igor Sikorsky, 2020. 259 p. Access mode: https://ela.kpi.ua/handle/123456789/42360*
2. *Systems and methods of decision support [Electronic resource]: textbook for applicants for a master's degree in the specialty 124 System Analysis / P. I. Bidyuk, O. L. Tymoshchuk, A. E. Kovalenko, L. O. Korshevnyuk; Igor Sikorsky Kyiv Polytechnic Institute. – Electronic text data (1 file: 3.13 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute 2022. – 610 p. – Access mode: https://ela.kpi.ua/handle/123456789/48418*
3. *Research of operations and methods of optimization in biology and medicine [Electronic resource]: textbook for applicants for a bachelor's degree in the educational program "Computer technologies in biology and medicine" of the specialty "Computer Science" / KPI. Igor Sikorsky; Gorodetska O. K., Zelensky K. Kh., Nastenko E. A., Pavlov V. A. – Kyiv: KPI. Igor Sikorsky, 2023. – 138 p. Access mode: https://ela.kpi.ua/handle/123456789/54465*

Educational content

5. Methods of mastering the academic discipline (educational component)

No. s/p	*Theme*	*Program learning outcomes*	*Main tasks*	
			Control West	*Term Execution*
1.	*Theoretical Foundations of Patient-Specific Prosthetics and 3D Modeling*	*PLO 5 PLO 20 PLO 23*	*Practical work 1*	*1st week*
2.	*Methods for processing medical images and creating three-dimensional anatomical models*	*PLO 5 PLO 20 PLO 23*	*Practical work 2*	*2nd week*
3.	*Engineering design and creation of complex 3D models of medical devices*	*PLO 5 PLO 20 PLO 23*	*Practical work 3*	*3rd week*
4.	*Optimization and engineering analysis of personalized treatment solutions*	*PLO 5 PLO 20 PLO 23*	*Practical work 4-5*	*4-5 weeks*
5.	*Innovative Technologies of Additive Manufacturing in Medicine*	*PLO 5 PLO 20 PLO 23*	*Practical work 6-7*	*Week 6-7*
8.	*Modular control work*	*PLO 5 PLO 20 PLO 23*	*Writing MKR*	*8th week*
9.	*Abstract*	*PLO 5 PLO 20 PLO 23*	*Execution and evaluation*	*7-8th week*

6. Independent work of a student

Types of independent work *(preparation for classroom lessons, calculations based on primary data obtained in laboratory classes, solving problems, writing an essay, performing calculation work, completing homework, etc.):*

№ s/n	Types of work submitted for independent work	Duration in hours IW
1	*Review of lecture material and study of questions assigned for independent work*	10
2	*Preparation for practical works*	30
4	*Preparation for modular control work*	4
5	*Performance of abstract work*	10
6	*Preparation for the Final test*	6
Total hours		60

Distribution of hours of independent work of students by educational content topics:

№ s/n	Titles of topics and questions to be studied independently and references to educational literature	Duration in hours IW
1	*Theoretical Foundations of Patient-Specific Prosthetics and 3D Modeling.* *List of issues submitted for independent study: prosthetic planning (removable, non-removable implants) [6].*	8
2	*Methods for processing medical images and creating three-dimensional anatomical models.* *The list of questions submitted for independent study: innovative applications in medicine, such as computational analysis [7, 8].*	8
3	*Engineering design and creation of complex 3D models of medical devices.* *The list of questions submitted for independent study: manufacturing of 3-dimensional devices (biomaterials and thermoplastics) [8, 9].*	8
4	*Optimization and engineering analysis of personalized treatment solutions.* *List of questions submitted for independent study: regenerative treatment methods involving living cells [10].*	8
5	*Innovative Technologies of Additive Manufacturing in Medicine.* *List of questions for independent study: templates for precise fit to the patient's anatomy [8].*	8
10	*Modular control work*	4
11	*Abstract*	10
12	*Final test*	6
Total hours		60

One of the main types of semester control during the mastering of the educational component is the preparation of an abstract. The abstract is performed in accordance with the requirements, within the time specified by the teacher.

An abstract is a scientific and technical document that contains comprehensive systematized information on the selected topic, provides for the presentation of material on the basis of specially selected literature and independently conducted research.

A student can write an essay only on a topic agreed with the teacher. The teacher offers essay topics in the classroom.

General requirements for the abstract:

- *clarity and logical sequence of presentation of the material;*
- *persuasiveness of argumentation;*
- *brevity and accuracy of wording, which exclude the possibility of ambiguous interpretation;*
- *specificity of the presentation of the research results;*
- *validity of recommendations and suggestions.*

The abstract should reflect:

- *relevance of the subject matter and correspondence to the current state of science, technology and production issues;*
- *justification of the chosen direction of research, methods of solving the problem and their comparative assessments;*
- *analysis and generalization of existing results;*
- *development of a general methodology for conducting research;*
- *the nature and content of the theoretical studies and calculations performed, research methods;*
- *justification of the need to conduct experimental research, the principle of operation of the developed programs, the characteristics of these programs, the assessment of calculation errors, the experimental data obtained;*
- *assessment of the completeness of the solution of the task;*
- *assessment of the reliability of the results obtained, their comparison with similar results;*
- *scientific and practical value of the work performed.*

Structure of the abstract: title page; content; list of symbols, symbols, units of abbreviations and terms (if necessary); introduction; the essence of the abstract (main part); conclusions; list of used sources (list of references); Appendices (if necessary).

The title page of the abstract 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 abstract; Student's surname and first name, course, academic group number, year.

The title page is followed by a detailed plan (content) of the abstract, in which it is necessary to highlight the introduction, sections of the main content (the main topics to be considered), their subsections (if necessary), conclusion, list of sources used. In the table of contents on the right, the page numbers of the beginning of each question are indicated. Each section starts with a new page.

The total volume of the abstract, depending on the chosen topic, can vary from 25 to 40 pages of the main text (in agreement with the teacher). The volume of the abstract is determined by the student's ability to briefly and at the same time comprehensively explain and analyze the information received in the medical information system specified by the teacher.

Mandatory requirement: a clear reference to sources of information. All figures, facts, opinions of scientists, quotes, formulas must be referenced in the form of [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 means the page number in this source). It is advisable to use tables, diagrams, graphs, diagrams, etc. The list of used sources (at least 10 sources) is drawn up in accordance with the 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.

The abstract is evaluated according to the following criteria: the logic of the plan; completeness and depth of disclosure of the topic; reliability of the data obtained; display of practical materials; the correctness of the formulation of the conclusions of the results and conclusions; registration; substantiation of the student's own opinion on this issue in the form of a conclusion.

Deadline for submitting an abstract for verification: 15-16th week of study.

The abstract is not checked for plagiarism, but must meet the requirements of academic integrity. In case of academic dishonesty, the work is annulled and not checked.

Policy and control

7. Policy of the academic discipline (educational component)

Violation of deadlines for completing tasks and incentive points

Incentive points		*Penalty points**	
Criterion	*Weight Score*	*Criterion*	*Weight Score*
Improvement of practical work	*1 point (for each practical work)*	*Untimely completion and defense of practical work*	*-0.5 points to -3 points (depends on the delivery date)*
Taking distance courses on topics that are agreed with the teacher	*5 points*	*Late execution and submission of the abstract*	*From -2 points to -10 points (depends on the due date)*
Registration of scientific work for participation in the competition of student scientific works	*10 points*		
Writing abstracts, articles, participation in international, all-Ukrainian and/or other events or competitions on the subject of the academic discipline	*5 points*		

** if the control measure was missed for a good reason (illness, which is confirmed by a certificate of the established form) – penalty points are not awarded.*

The total amount of penalty points does not exceed 10% of the total amount of points that can be scored per semester, i.e. no more than 10 points.

Attending classes

Attending lectures is not mandatory. Attending practical classes is desirable, since they are used to write express tests / test tasks, as well as explain the performance of subsequent practical works and their delivery.

The assessment system is focused on obtaining points for the student's activity, as well as performing tasks that can develop practical skills and abilities.

Missed control measures

Missed control measures (defense of practical work) must be worked out in the next lessons, provided that the task that is planned for the current lesson is completed, or at consultations.

Skipping the writing of modular tests and express tests are not practiced.

An abstract submitted for verification in violation of the deadline is evaluated with a decrease in the number of weight points.

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

The norms of ethical behavior 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 details: 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 dealt with according to predetermined procedures.

The 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. NON/128/2021 of 20.05.2021) - https://osvita.kpi.ua/index.php/node/182

Inclusive learning

The educational component can be taught for most students with special educational needs, except for students with severe visual impairments who do not allow them to complete tasks using personal computers, laptops and/or other technical means.

Distance learning

Distance learning takes place through the Sikorsky Distance Learning Platform.

Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students want to take an online course on a certain topic, the study of the material with the help of such courses is allowed, but students must complete all the tasks that are provided for in the academic discipline.

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

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

Practical work, as well as the implementation of the abstract, is carried out during the independent work of students in remote mode (with the possibility of consulting with the teacher via e-mail, social networks).

Learning in a foreign language

Education in English is provided only for international 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 topic of specific classes.

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

Evaluation system (current control):

№ salary	Control measure	%	Weight Ball	Quantity	Total
1.	Express tests / test tasks	28	2	14	28
2.	Performance and defense of practical work	42	6	7	42
3.	Modular control work	12	12	1	12
4.	Abstract	18	18	1	18
5.	Credit work[1]	82	82	1	82
	Total				100

[1] *It is taken into account in the amount of the rating along with the grade for the essay if the student did not score 60 points for the semester or he wants to improve his grade.*

An applicant receives a positive credit score based on the results of work in the semester if he has a final rating for the semester of at least 60 points and has fulfilled the conditions for admission to semester control, which are determined by the RSO.

With applicants who have fulfilled all the conditions for admission to the test and have a rating score of less than 60 points, as well as with those applicants who want to increase their rating score, at the last scheduled lesson in the discipline in the semester, the teacher conducts semester control in the form of a test work or an interview.

After completing the test work, if the grade for the test work is higher than for the rating, the applicant receives a grade based on the results of the test work.

If the grade for the test work is less than for the rating, the "hard" RSO is applied – the applicant's previous rating (except for the points for the semester individual task) is canceled and he receives a grade taking into account the results of the test work. This option forms a responsible attitude of the applicant to making a decision to perform the test work, makes him critically assess the level of his training and carefully prepare for the test.

In case of detection of academic dishonesty during training, the control measure is not counted.

***Calendar control** (CC) is not carried out.*

Semester certification of students

	A prerequisite for admission to the test	***Criterion***
1	*Current Ranking*	*RD ≥ 30*
2	*Receiving a positive assessment for the completed abstract*	*More than 6 points*
3	*All practical work is protected*	*More than 0 points*
4	*Writing at least 6 express tests / test tasks*	*More than 6 points*

The results are announced to each student separately in the presence of a control event or in a remote form (e-mail). They are also recorded in the "Electronic Campus" system.

Optional conditions for admission to the test:

1. *Activity in practical classes.*
2. *Attending lectures.*

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

Number of points	*Score for University scale*
100-95	*Excellent*
94-85	*Very good*
84-75	*Good*
74-65	*Satisfactory*
64-60	*Dostagno*
Less than 60	*Unsatisfactory*
Not met the conditions of admission	*Not allowed*

The test is carried out orally.

9. Additional information on the discipline (educational component)

Appendix 1. Program learning outcomes (extended form)

In accordance with the Order of the Ministry of Education and Science of Ukraine No. 1204 of 19.11.2018 "On Approval of the Standard of Higher Education in the Specialty 163 Biomedical Engineering" for the First Bachelor's Level of Higher Education" in Annex 1 establishes the correspondence of the learning outcomes to the competencies in the discipline "Information Support of Diagnostic and Treatment Processes of Patients with Lost Limbs".

Appendix 2. Questions to prepare for the modular test

The list of questions for preparation for the modular test, as well as for preparation for the test, is given in Appendix 2.

Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students want to take an online course on a certain topic, the study of the material with the help of such courses is allowed, but students must complete all the tasks that are provided for in the academic discipline.

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

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

Work program of the academic discipline (syllabus):

Compiled *by the Head of the Department of Biomedical Engineering, Doctor of Technical Sciences, Associate Professor, Shlykov Vladyslav Valentynovych, Department of Biomedical Engineering.*

Approved *by the Department of Biomedical Engineering (Minutes No. 16 dated June 21, 2024)*

Approved *by the Methodological Commission of the Faculty of Biomedical Engineering (Minutes No. 9 dated June 26, 2024)*

Program learning outcomes (extended form)

As a result of studying the discipline "Microprocessor Technology", students will be able to:

Learning outcomes		Compliance with learning outcomes to competencies in the SVO [6]	
		General Soft **Skills**	Special Competencies (**Professional**)
PLO 2	*Formulate logical conclusions and reasonable recommendations for the assessment, operation and implementation of biotechnical, medical-technical and bioengineering means and methods.*	*GC 1 - Ability to apply knowledge in practical situations*	
PLO 5	*Be able to use databases, mathematical and software for data processing and computer modeling of biotechnical systems.*		*PC 1 - Ability to apply engineering software packages for research, analysis, processing, and presentation of results, as well as for automated design of medical devices and systems.*
PLO 20	*Knowledge and use of methods of research of objects of biomedical engineering, methods and means of systematization and processing of experimental information, methods of statistical processing for modeling and simulation of processes and systems of physical and biological nature, modern programming technologies and tools that support their use, methods of designing digital and microprocessor systems for medical purposes.*		*PC 11 - Ability to develop, plan, and conduct experiments using specified technical and biomedical techniques, applying mathematical methods in the analysis and modeling of the functioning of living organisms, systems, and processes in biology and medicine, computer processing, analysis, and synthesis of the obtained results.*
PLO 23	*Development and implementation of modern diagnostic and therapeutic methods that are associated with the use of biotechnology, computer and nanotechnology due to the*	*GC 2 - Knowledge and understanding of the subject area and understanding of professional activities.*	

Learning outcomes		Compliance with learning outcomes to competencies in the SVO [6]	
		General Soft **Skills**	Special Competencies (**Professional**)
	improvement of technical elements of medical devices and systems and medical products in the process of professional activity.		

[6] Order of the Ministry of Education and Science of Ukraine No. 1204 of 19.11.2018 "On Approval of the Standard of Higher Education in the Specialty 163 Biomedical Engineering" for the First Bachelor's Level of Higher Education".

List of questions to prepare for the modular test work,

as well as to prepare for the exam

1. *Modern engineering and technological approaches in prosthetics and patient-specific implantation.*
2. *The concept of "informatization society". Stages of formation.*
3. *3D data formats, methods for converting two-dimensional images into three-dimensional models, and basic principles of building 3D structures.*
4. *Patient-specific 3D modeling and design of prostheses, taking into account technical requirements and principles of design individualization.*
5. *Using medical CT/CBCT images to create patient-specific models.*
6. *DICOM standard.*
7. *Analysis and processing of medical images to build three-dimensional anatomical models.*
8. *Medical Imaging Artifacts: Causes, Physical Mechanisms, and Methods to Eliminate Them.*
9. *Creation of three-dimensional models based on CT and CBCT data. Segmentation.*
10. *Creation of three-dimensional models based on CT and CBCT data. Reconstruction and visualization of anatomical structures.*
11. *Virtual planning of surgical interventions using three-dimensional anatomical models.*
12. *3D engineering design methods for additive manufacturing of medical devices.*
13. *Principles of creating complex geometric shapes and functional structures in patient-specific products.*
14. *Design of implants and prostheses taking into account the individual anatomical and biomechanical characteristics of the patient.*
15. *Development of patient-specific surgical guides to improve the accuracy and safety of surgical interventions.*
16. *Consideration of boundary conditions when building calculation models.*
17. *Analysis of the stress-strain state of medical devices and interpretation of calculation results.*
18. *Methods for optimizing personalized design strategies based on three-dimensional modeling.*
19. *Optimization of patient-specific product design processes using algorithmic approaches.*