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

Department of
biomedical engineering

Laboratory analytical equipment

Working program of basic discipline (Syllabus)

Requisites for basic discipline	
Level of higher education	***First (bachelor's)***
Branch of knowledge	***16 Chemical and Bioengineering***
Specialty	***163 Biomedical Engineering***
Educational program	***Medical engineering***
Discipline status	***Selective discipline***
Form of study	***full-time / day / mixed / remote***
Year of preparation, semester	***4th course, autumn semester***
The scope of discipline	***4 ECTS credits / 120 hours***
Semester control / Control measures	***Test Work, Modular Test Work, Abstract***
Lessons schedule	***According to the schedule on the site https://schedule.kpi.ua/***
Language of instruction	***English, Ukrainian***
Information about course leader / teachers	***Lecturer: Associate Professor,Bogomolov Mykola,*** nbogom@yahoo.com; mfbogomolov@gmail.com; m.bogomolov@kpi.ua ***Practical: Associate Professor,Bogomolov Mykola,*** nbogom@yahoo.com; mfbogomolov@gmail.com; m.bogomolov@kpi.ua ***Zoom: 779 2233 9663, code 7Pzg7d***
Teacher's profile	***Lecturer:*** **http://intellect.bmi.fbmi.kpi.ua/profile/bmf**
Course placement	***Platform «Sikorsky»*** **https://do.ipo.kpi.ua/ course/view.php?id=2613**

Distribution of hours

Semester	Lectures	Practical	Laboratory	Independent Student Work (ISW)
Spring semester	*26*	*28*	*--*	*66*

Curriculum of the discipline

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

The purpose of the discipline. *The main purpose of the discipline* ***" Laboratory analytical equipment "*** *is to form students' ability to choose basic and auxiliary materials, methods and tools for the implementation of technical projects, to apply modern methods and methods of modeling in the design of medical equipment and medical devices; to carry out experiments according to the set technical and medical methods, to carry out computer processing, the analysis and synthesis of the received results.*

Teaching methods

Lectures *are held using the explanatory-illustrative method, the method of problem statement, interactive method during lectures, which is used to establish a dialogue with the audience.*

Practical classes *are held using:*

1) Reproductive method, through which students consolidate the studied theoretical material and learn to use it in specific scientific problems.

2) Partial search, or heuristic method, which teaches the search for the right ways and methods of solving problems.

3) Interactive method used during practical classes to involve students in problem-solving processes and theoretical facts used for this purpose. Presentation and discussion of the obtained results involves the use of problem-based and interactive teaching methods.

Applicants independently *study the literature, software tools for the design of medical devices and systems, medical monitoring and forecasting systems, Internet metrology systems and diagnostic devices. For original solutions, educational work can grow into scientific research.*

Skills required to study the discipline:

1. Knowledge and ability to use Microsoft Word, Microsoft PowerPoint.

2. Ability to abstract thinking, analysis and synthesis of new technologies using modern physiotherapy techniques, medical protocols and medical devices.

3. Ability to search, process, analyse scientific and technical information from various sources for optimal use and implementation of medical and technical requirements for the use of modern medical treatment technologies.

4. Knowledge of a foreign language.

5. Ability to work in a team of like-minded people and specialists in various fields of knowledge.

6. Ability to work in an international context to participate in comprehensive testing and advertising of research achievements in the implementation of modern physiotherapeutic treatment technologies.

7. Ability to analyse complex medical engineering and bioengineering problems and tasks, to formalize them to find quantitative solutions using modern statistical mathematical methods and microcomputer information technologies.

8. Ability to study biological and technical aspects of functioning and interaction of artificial biological neural networks and biotechnical systems.

9. Technical means of automated design medical equipment and systems.

10. Software tools for creating biomedical laser systems and optoelectronic elements.

11. Analysis of optical and mechanical components of therapeutic medical devices by finite element method (FEM).

Software competencies

Integral competence

IK	***The ability to solve complex tasks and problems in biomedical engineering or in the process of learning, which involves conducting research and/or implementing innovations and is characterized by uncertainty of conditions and requirements***

Studying the educational component strengthens the following general competencies:

ZK 1	***Ability to apply knowledge in practical situations (Reinforcement).***
ZK 2	***Knowledge and understanding of the subject area and understanding of professional activity (Reinforcement).***
ZK 4	***Skills in using information and communication technologies (Reinforcement).***

ZK 13	The ability to preserve and multiply the moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technology and engineering, to use various types of physical activity for active recreation and leading a healthy lifestyle (Reinforcement).
	Skills in using information and communication technologies in the design and operation of laboratory analytical equipment.
	Ability to evaluate and ensure the quality of work performed in the design and operation of laboratory analytical equipment.

Studying the educational component strengthens the following special (professional) competencies:

FK 2	Ability to provide engineering and technical expertise in the planning, evelopment, evaluation, and specification of medical equipment (Reinforcement).
FK 7	Ability to plan, design, develop, install, operate, maintain, service, control and coordinate the repair of devices, equipment and systems for prevention, diagnosis, treatment and rehabilitation used in hospitals and research institutes (Reinforcement).
FK 12	Ability to ensure and monitor compliance with safety and biomedical ethics when working with medical equipment (Reinforcement).
	Ability to provide engineering expertise in the planning, development, evaluation, and specification of modern laboratory analytical equipment.
	Ability to apply physical, chemical, biological and mathematical methods in analysis, modeling the functioning of modern laboratory analytical equipment.
	The ability to identify, formulate, and solve engineering problems related to the interaction between living and non-living systems in the design and operation of modern laboratory analytical equipment.
	The ability to conduct experiments according to specified technical and medical methods, perform computer processing, analysis and synthesis of the results obtained when operating modern laboratory analytical equipment.

Studying the educational component reinforces the following program learning outcomes:

PRN 3	Manage complex activities or projects, be responsible for making engineering decisions in unpredictable conditions, conduct feasibility and safety assessments of projects (Reinforcement).
PRN7	Provide engineering support, service, and technical maintenance during the operation of laboratory analytical equipment, medical diagnostic and therapeutic complexes and systems in accordance with the rules established by technical documentation and regulatory documents governing the procedures for commissioning, application, and repair of medical equipment, as well as to form the standard documentation by types of work according to the technical regulation on medical devices (Reinforcement).
PRN10	Be able to plan, organize, direct and control medical and bioengineering systems and processes (Reinforcement).
PRN13	Be able to analyze signals transmitted from organs to devices and process diagnostic information (signals and images) (Reinforcement).

PRN22	***Knowledge of general principles and structure of complex biological systems, including the human body and its functions from the perspective of a systemic approach and their utilization in biomedical engineering, as well as basic methods and tools used for quantitative assessment of physiological system functioning (Reinforcement).***
PRN 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 (Reinforcement).***
PRN24	***Being able to consider historical, social, environmental, ethical, legal, economic aspects, requirements of labor protection, industrial hygiene, and fire safety when forming technical solutions, taking into account the strengthening and preservation of personal and public health (Reinforcement).***
	Formulate logical conclusions and substantiated recommendations regarding the evaluation, operation and implementation of modern laboratory analytical equipment, medical and bioengineering tools and methods.
	Apply the provisions of regulatory and technical documents that regulate the procedure for product certification and certification of the production of modern laboratory analytical equipment.
	Be able to use databases, mathematical and software for data processing and computer modeling of modern laboratory analytical equipment.
	Knowledge of methods for studying objects, analyzing and processing experimental data in laboratory research using modern laboratory analytical techniques.
	Be able to analyze signals transmitted from organs to devices and process diagnostic information (signals and images) for the successful and effective application of modern laboratory analytical techniques.
	Possession of modern methods for testing the experimental integrity and performance of modern laboratory analytical equipment and determining their optimal characteristics.

Program learning outcomes, assessment measures, and deadlines are announced to students at the first lesson.

Subject of the discipline " Laboratory analytical equipment ".The discipline belongs to the cycle of elective disciplines of professional training of a specialist in the specialty ***163 "Biomedical Engineering"*** in the specialization **"Medical Engineering"** of the first (bachelor's) level of higher education for bachelor's degree, which provides training of specialists with higher education. Research of human diseases used in laboratory analytical equipment, which will allow to design and operate highly efficient diagnostic optoelectronic devices, perform their repair and maintenance, conduct research on the effects of various harmful external factors on the human body. The practical part is aimed at direct acquaintance with medical diagnostic technologies and relevant modern medical equipment directly in medical institutions: scientific and analytical review, design, construction, research, testing, operation and technical expertise, engineering and information support of laboratory analytical equipment and technologies, computer based processing of experimental medical information and signals to identify the presence of pathological areas, organs and tissues.

During training the following are applied: - teaching methods: communicative, problem-searching, research, explanatory-demonstration, partial-search, method of educational projects; -implemented: lecture courses, seminars and practical classes, computer workshops and laboratory work, course projects, consultations, independent training in library collections, use of Internet resources, application of information and communication technologies (e-learning, online lectures, distance courses), performance of a qualifying diploma work of the bachelor; - strategies of active and

collective learning; - personality-oriented development technologies based on active forms and teaching methods (team-based learning), pair work (think-pair-share), brainstorming method, case study method, business games, discussion etc.); - heuristic methods (methods of creating ideas, methods of solving creative problems, methods of creative thinking activation); - method of problem-oriented learning.

For more effective communication in order to understand the structure of the discipline and master the material using e-mail and ***WhatsApp messenger***, ***Skype***, platform ***https://do.ipo.kpi.ua*** through which: - simplifies the placement and exchange of educational material; - provides feedback to students regarding learning tasks and the content of the discipline; - students' learning tasks are evaluated; - the account of performance by students of the plan of educational discipline, the schedule of performance is conducted learning tasks and student assessment. During the training and for interaction with students, modern information and communication and network technologies are used to solve educational tasks such as **ZOOM** and **Cisco Webex Meetings**, as well as equipment (projector and electronic presentations for lectures and practical classes).

Program learning outcomes: As a result of studying the discipline ***" Laboratory analytical equipment "*** students will be able to:

1. Choose the basic and auxiliary materials, methods and tools for the implementation of technical projects, to apply modern methods and methods of modeling in the design of medical equipment and medical devices.
2. Use methods and means of quantitative assessment of the functioning of physiological systems in practical engineering activities.
3. Implement modern diagnostic and treatment methods related to the use of biotechnology, computer and nanotechnology.
4. Conduct experiments according to specified technical and medical methods, perform computer processing, analysis and synthesis of the results
5. Implement modern diagnostic and therapeutic methods related to the use of biotechnology, computer and nanotechnology.
6. Improve the technical elements of medical devices and systems in the process of professional activity.
7. Apply methods and tools for forecasting and modeling to study the behavior and properties of biological systems.
8. Work with information: find, evaluate and use information from various sources needed to solve scientific and professional problems.

The compliance of learning outcomes with the competencies according to the standard of higher education can be viewed in ***Annex 1 "Program learning outcomes (extended form)".***

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

The discipline ***" Laboratory analytical equipment "*** is interdisciplinary. It integrates with its subject knowledge from other educational and scientific fields, in the structural and logical scheme of the training program that provides the following disciplines and credit modules:

1) Mathematical modelling and simulation of biomedical systems; 2) Modelling of biophysical systems and processes in medicine; 3) Mathematical methods of optimizing of biomedical signals and images; 4) Methods of identification, processing and optimization of medical information; 5) Quantitative physiology; 6) Instrumental methods of diagnosing human health, as well as disciplines of the unit of language and practical training.

The discipline ***" Laboratory analytical equipment "*** is the basis for the preparation of bachelor's theses (projects, master's theses) in the specialty and in further practical work in the specialty.

- from selective disciplines (educational-professional program **"Biomedical Engineering"**): **"Medical Equipment", "Prosthetics and artificial organs", "Biomedical devices and systems".**

3. The content of the discipline

Program learning outcomes, control measures and deadlines are announced to students in the first lesson.

№ s/n	*Subject*	*Program learning outcomes*	*The main tasks*	
			Control measure	*Deadline*
1.	**General concepts of laboratory equipment. Features of regulatory and technical documentation.**	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work 1, 2***	***3rd week***
2.	**Carrying out elementary laboratory procedures. Features of the operation of laboratory and analytical equipment.**	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work 3,4***	***4th week***
3.	**Optical methods in laboratory diagnostics. Engineering support and methodology.**	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work* 5-8**	**5-6*th weeks***
4.	**Electrochemical research methods. A systematic approach to laboratory research.**	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work* 9-10**	**7-8*th weeks***
5.	**Biochemical research. Microscopy. Modern diagnostic biotechnologies.**	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work* 11-12**	**9-10*th weeks***
6.	**Methods based on specific binding of substances by ligands (ligand technologies). Sanitary safety requirements for research.**	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work* 13-14**	**11-12*th weeks***
7.	**The use of radioactivity in laboratory medicine. Features of certification and verification of analytical equipment.**	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work* 15-18**	**13-14*th weeks***
8.	**Molecular biological technologies. General clinical research, methods of analysis of experimental data of medical technology.**	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Registration and submission of Home Control Work***	**15-16*th weeks***

9.	**Automation of laboratory research. Modern methods of testing for experimental integrity, determination of their optimal characteristics.**	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Abstract,Test***	**17-18*th weeks***

4. Training materials and resources

Basic literature:

1. . Богомолов, М. Ф. Лабораторна аналітична техніка. Конспект лекцій до вивчення кредитного модуля дисципліни «Методи та засоби діагностики-1. Лабораторна аналітична техніка» для студентів спеціальності 163 «Біомедична інженерія» та 152 «Метрологія та інформаційно-вимірювальна техніка» [Електронний ресурс] : навчальний посібник для студентів спеціальності 163 «Біомедична інженерія» та 152 «Метрологія та інформаційно-вимірювальна техніка» / Богомолов М. Ф., Шликов В. В. ; КПІ ім. Ігоря Сікорського. – Електронні текстові дані (1 файл: 3,38 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2020. – 69 с.
2. Bogomolov M.F. Development and operation of physiotherapeutic medical devices: lecture notes for the study of the discipline " Development and operation of physiotherapeutic medical devices " [Electronic resource]: a textbook for bachelor's degree in specialty 163 - "Biomedical Engineering", specialization "Medical Engineering" / KPI. Igor Sikorsky; structure. M.F. Bogomolov, V.V. Shlykov, M.M. Sychyk – Kyiv: KPI Igor Sikorsky, 2023. – 60 p. Дата затвердження: 2023-06-02 Номер протоколу: 8 Примірник надано до бібліотеки у: - електронній формі: **ttps://ela.kpi.ua/handle/123456789/57376 .**
3. Лабораторна аналітична техніка: Лабораторний практикум [Електронний ресурс]: навч. посіб. для студ. спеціальності 163 «Біомедична інженерія» та 152 «Метрологія та інформаційно-вимірювальна техніка», спеціалізації «Клінічна інженерія» / М.Ф. Богомолов, С.І. Вовянко, В.В.Шликов– Київ: КПІ ім. Ігоря Сікорського,2018.-120с.; Url:http://ela.kpi.ua/handle/123456789/25316;2.

Additional literature (electronic resources):

1.Ukraine WHO Special Initiative for Mental Health Situational Assessment – Washington: UNIVERSITY of Washington, 2020. – 10 c.

2. Linehan C. Exploring the prevalence and profile of epilepsy across Europe using a standard retrospective chart review: Challenges and opportunities / C. Linehan, A. Benson, A. Gunko. // Epilepsia. – 2021. – №62. – С. 2651 – 2666.

3. Fisher R. Практичне клінічне визначення епілепсії / R. Fisher, C. Acevedo. // Epilepsia. – 2014. – №55. – С. 475–482.

4. Chang B. Epilepsy / B. Chang, D. Lowenstein. // The New England Journal of Medicine. – 2003. – №349. – С. 1257–1266.

5. An Introduction to Epilepsy [Електронний ресурс] // National Library of Medicine. – 2006. – Режим доступу до ресурсу: https://www.ncbi.nlm.nih.gov/books/NBK2510/.

6. Westmoreland B. Epileptiform Electroencephalographic Patterns / Westmoreland. // Mayo Clin Proc. – 1669. – №701. – С. 501 – 511.

7. Melinosky C. What Are the Treatments for Epilepsy? [Електронний ресурс] / Melinosky //

WebMD. – 2023. – Режим доступу до ресурсу: https://www.webmd.com/epilepsy/treating-epilepsy.

8. Seppo A. Overview of MEG / Seppo. // Organizational Research Methods. – 2016. – №22.

9. Vivekananda U. Redefining the role of Magnetoencephalography in refractory epilepsy / Vivekananda. // Seizure. – 2020. – №83. – С. 70–75.

10. Brookes M. Magnetoencephalography with optically pumped magnetometers (OPM-MEG): the next generation of functional neuroimaging / M. Brookes, J. Legget. // Trends in Neurosciences. – 2022. – №45. – С. 621– 634.

11. Brickwedde M. Applications of OPM-MEG for translational neuroscience: a perspective / M. Brickwedde, P. Anders. // Translational Psychiatry. – 2024. – №14.

12. Tierney T. Optically pumped magnetometers: From quantum origins to multi-channel magnetoencephalography / T. Tierney, N. Holmes. // NeuroImage. – 2019. – №199.

13. Migliorelli C. Methods for noninvasive localization of focal epileptic activity with magnetoencephalography : дис. докт. мед. наук / Migliorelli – Barcelona, 2017. – 163 с.

Electronic resources:

1. http://info-library.com.ua/books-text-4072.html.
2. http://www.twirpx.com.
3. **Electronic campus. Teacher MF Bogomolov.**
4. http://info-library.com.ua/books-text-4072.html.
5. http://www.twirpx.com.
6. http://ela.kpi/handle/123456789/7739 .
7. http://info-library.com.ua/books-text-4072.html .
8. http://ela.kpi/handle/123456789/11560.
9. http://ela.kpi.ua/handle/123456789/16554.

Educational content

5. Methods of mastering the discipline (educational component)

Information (by sections, topics) about all classes (lectures, practical, seminar, laboratory):

Names of sections and topics	Number of hours					
	Total	including				
		Lectures	Practical (seminar)	Computer workshops	Laboratory	Independent student work
1	2	3	4	5	6	7
Section 1. Laboratory diagnostics as an integral part of the clinical examination of the patient: key concepts, terminology. Physico-chemical methods in laboratory analysis.						
Topic 1.1. General concepts of laboratory equipment.	11	4				6
Topic 1.2. Equipment for basic laboratory procedures.	9	2	2			5
Topic 1.3. Separation Methods.	10	2	2			6
Topic 1.4. Optical methods in laboratory diagnostics.	13	6	4			3
Total by Section 1	**42**	**14**	**8**			**20**

Names of sections and topics	Number of hours					
	Total	including				
		Lectures	Practical (seminar)	Computer workshops	Laboratory	Independent student work
Section 2. Physico-biological technologies. Leading general clinical and biochemical research.						
Topic 2.1. Biochemical research.	10	2	2			6
Topic 2.2. Methods based on the specific binding of substances by ligands (ligand technologies).	11	1	4			6
Topic 2.3. Application of radioactivity in laboratory medicine.	4.5	1	2			1.5
Topic 2.4. Molecular biological technologies.	19	2	4			13
Topic 2.5. Microscopy.	8.5	2	2			4.5
Topic 2.6. General clinical studies.	8	2	2			4
Topic 2.7. Automation of laboratory research	12	2	2			8
Total by Section 2	**73**	**12**	**18**			**43**
Modular control work	5		2			3
Test	8					8
Total hours	**120**	**26**	**28**	**–**	**–**	**66**

Recommendations for mastering training sessions (in the form of a detailed description of each lesson and planned work):

Lectures

List of didactic tools for lectures: Lecture notes, projection multimedia equipment; Power Point presentation.

№ s/n	Title of the lecture topic and list of main questions (list of didactic tools, references to literature and tasks on ISW)	Hours
1	**Tasks of clinical laboratory diagnostics. Main directions of clinical laboratory diagnostics. Departments of clinical diagnostic laboratories. Concepts: material, reagents, equipment. Requirements for premises and equipment. Concepts of specificity and sensitivity. Accreditation of measuring laboratories. Equipment - general purpose and special.** **Literature [1] – P. 425, [2] – P. 5-38.** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources**.**	2
2	**Equipment for elementary laboratory procedures.** **General purpose equipment. Equipment and methods for cleaning laboratory glassware. Water treatment systems (water purification by distillation,**	2

	deionization, reverse osmosis). Thermoclimatic equipment. Equipment for determining mass. Dosers: single-channel, multi-channel, dispensers. **Literature [2] – C. 40-54.** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources.	
3	**Methods of separation of liquid heterogeneous systems.** **Apparatus for separation of liquid heterogeneous systems by centrifugation. Types of centrifuges. Structure of centrifuges. Calculation of centrifugation parameters.** **Literature [1] – C.438 – 442.** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[1,c.34-67;17,c.67-109;19,c.34-79].**	**2**
4	**Separation methods.** **Chromatography methods. Gel chromatography. Chromatography on supports. Gas chromatography. HPLC. Chromatography materials and equipment. Vertical electrophoresis. Electrophoresis equipment. Mass spectrometry and mass spectrometers.** **Literature [8, c.97-140;11, c.96-126; 21, c.76-105].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[6,c.45-77;16,c.34-67;19,c.34-92].**	**2**
5	**Photometric methods in laboratory diagnostics.** **The law of Bouguer-Lambert-Beer. Photometers and spectrophotometers.** **Schematic diagram of a photometer. Optical diagram of a photometer and spectrophotometer. Light filters. Monochromators. Resolution of monochromators. Accuracy of wavelength setting.** **Literature [6, c.55-78; 11, c.66-98; 20, c.71-129].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[5,c.44-76;8,c.28-49;12,c.56-87;18,c.75-107;18,c.61-84].**	**2**
6	**Fluorimetry and luminometry.** **Phenomena of fluorescence and luminescence. Stokes-Lommel rule. Fluorescence quantum yield. Fluorimeters and luminometers. Features of the optical scheme of the devices. Sensitivity of methods. Fluorescent dyes. Fluorescent labels. Fluorescent probes.** **Literature [1, c. 44-96; 3, c.55-97; 16, c.112-139; 17, c.105-123].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[4,c.44-67;8,c.106-118;11,c.74-109].**	**2**
7	**Electrochemical research methods.** **The concept of potentiometric methods. The design of pH meters, ionometers. Types of electrodes. Electrochemiluminescent analysis.** **Literature [5, c.97-114; 8, c.106-123; 11, c.96-117].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[4,c.55-87;10,c.124-137;16,c.84-91].**	**2**
8	**Methods and tools of clinical biochemistry.** **The concept of chromophore, auxochrome. Application of photometric methods for quantitative assessment of the results of biochemical studies. Endpoint measurement. Kinetic methods. Determination of enzyme activity. General principles of the design of biochemical analyzers. Types of biochemical analyzers.** **Literature [7,c.65-98; 11, c.76-93; 18, c.117-134].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[2,c.34-67;15,c.79-123;17,c.104-129].**	**2**
9	**Ligand technologies.** **Antigen-antibody interaction. Application of enzyme-linked immunosorbent assay in diagnostics. Equipment for enzyme-linked immunosorbent assay. Immunophenotyping. Biochips and biosensors. Radioimmunoassay. Sensitivity of the method. Conditions for safe use.Literature [11, c.129-135; 13, c. 91-103; 16,**	**2**

	c.120-137; 18, c.93-105; 120, c .112-130]. **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[6,c.126-137;17,c.89-107;20,c.114-129].**	
10	**Molecular biological technologies.** **Application of the polymerase chain reaction method in clinical diagnostics. Organization of the technological process. Equipment for PCR. Real-time PCR.** **Literature** [2] – C. 366-415.. **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources**.**	**2**
11	**Microscopy.** **History of the method. Resolution of microscopes. Types of microscopes. Structure of an optical microscope. Phase-contrast microscopy. Fluorescence microscopy.** **Literature** [1] – Гл. 22, 23, [2] – C.326 – 344, [3] – §15.1, 15.3. **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources**.**	**2**
12	**Hematological studies.** **Main characteristics of blood cells. Basic principles implemented in hematological analyzers. Their structure and software. Classes of hematological analyzers. VCS principle. Flow cytofluorimetry.** **Literature [2] – C. 344-363.** **Tasks on ISW: To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources.**	**2**
13	**Automation of laboratory research.** **Semi-automatic and automatic methods. Laboratory analytical systems. Cobas Integra 2000.** **Literature [2] – C.494 – 499, C.580-630.** **Tasks on ISW: To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources.**	**1**
14	**Principles of unification and standardization of clinical laboratory research methods.** **Analytical, medical, technical and economic criteria for unification. GLP and GCP rule systems. Quality control of clinical laboratory research. Laboratory accreditation.** **Literature [2] – C.24 – 60, [5], [6].** **Tasks on ISW: To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources.**	**1**
Total hours		**26**

Practical The main tasks of the series of practical classes: consolidation in practice of the main provisions of the discipline ***" Laboratory analytical equipment "*** and basic laboratory methods, schematic diagrams of laboratory equipment, to master practical skills of calculating parameters by performing specially formulated tasks and real circuit design options for printed modules and equipment, which is actually projected in the bachelor's theses of students. The practical lesson includes control of knowledge, skills and abilities, solving real problems of designing biomedical equipment with their discussion, solving control problems, their verification and evaluation.

Grades received by the student for individual practical classes are registered in the journal of classes of the study group and are taken into account when determining the final grade (rating) for this discipline.

№ s/n	**Class Subject Name**	**Hours**
1	**Equipment for water purification by distillation, deionization, reverse osmosis.** Distillers, their purpose, structure. Devices for deionization, their purpose, structure. Devices for water purification by reverse osmosis. Comparison of the effectiveness	**2**

	of methods for purification from various types of impurities. **Literature** [2] – P. 40-54. **List of didactic aids:** projection multimedia equipment, tables of physical constants, computing equipment. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	
2	**Thermoclimatic equipment**.Purpose of thermoclimatic equipment. Its types. Types of temperature control sensors. **Literature** [1] – P. 58-81. **List of didactic aids:** projection multimedia equipment, tables of physical constants, computing equipment. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**2**
3	**Separation methods.** Principles of electrophoresis. Horizontal electrophoresis - on paper, on an acetate-cellulose substrate. Determination of the migration speed of proteins depending on the parameters of the electric field. The ratio of protein fractions in human blood serum in normal and pathological conditions. **Literature** [1] – P. 438-442. **List of didactic aids:** projection multimedia equipment, tables of physical constants, computing equipment. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**2**
4	**Photometry in laboratory diagnostics.** The law of Bouguer-Lambert-Beer. Calculation of the molar extinction coefficient. Calculation of the concentration of a substance in a solution using a calibration graph. Schematic diagram of a photometer. Optical diagram of a photometer and spectrophotometer. Light filters. Monochromators. Their characteristics. **Literature** [1] – P.426 – 433, [2] – P.230- 252. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**2**
5	**Fluorimeters and luminometers.** Physical foundations of the phenomenon of fluorescence. Fluorescence quenching. Calculation of the quantum yield of fluorescence. Features of the optical scheme of a fluorometer. Features of the optical scheme of a luminometer. Measurement of flash and glow fluorescence. **Literature** [1] – P.426 – 433. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**2**
6	**Electrochemical research methods.** Construction of pH meters, ionometers. Types of electrodes. **Literature** [1] – P. 387-394. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**2**
7	**Biochemical analyzers.** Schematic diagram of a biochemical analyzer. Reagent block. Sample block. Reaction block. Temperature control block. Electrical diagrams of the LabLine analyzer. **Literature** [1] – P. 433-438, [2] – 3. 284-300, 441-484. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these	**2**

	sections based on the lecture notes.	
8	**Enzyme-linked immunosorbent assay.** Types of enzyme-linked immunosorbent assay, their comparison, sensitivity. Equipment for ELISA. Multichannel dispensers. Structure of a microplate reader. Structure of a washer. Incubator-shaker for microplates. Consideration of the detailed structure using the example of an automatic Chemwell analyzer. **Literature** [2] – P.284-300, 441-461. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**2**
9	**Polymerase chain reaction method and equipment for its implementation.** Organization of the technological process and equipment for PCR. Application of the PCR method in clinical diagnostics - consideration of examples of PCR types and detection methods. Implementation of the method in a virtual laboratory. **Literature** [1] – P. 442-449, [2] – P. 366-415. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**2**
10	**Hematological analyzers.** Indicators of general clinical blood analysis. Complete blood count. Hematological analyzers: structure and software. **Literature** [1] – P. 442-449, [2] – P. 344 – 360. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**2**
11	**Flow cytofluorimetry.** Flow cytometer structure. Principles used in flow cytometers. Conductometry. Forward and side scatter. Fluorescence measurement. **Literature** [2] – P. 344 – 363. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**2**
12	**Automation of laboratory research.** Consideration of the need for semi-automatic or automatic methods depending on the capacity of the laboratory. Laboratory automatic systems. Laboratory information systems. **Literature** [2] – P.494 – 499, P.580-630. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**2**
13	MKR: Conducting a final thematic control of sections 1-2. **Literature** [1] – P.58 – 94, P.425-449; [2] – P.67 – 630. **Tasks for the SRS:** Study the lecture material, prepare for practical classes on these sections based on the lecture notes.	**4**
Total hours		**28**

Individual tasks

From this credit module the individual task in the form - **Modular test work (MTW)** is planned.

The main goals of the individual task:

Modular test work (MTW) is an ongoing control measure that covers the practical skills of using science tools to quantify, analyze and evaluate functional systems and processes of interacting natural and artificial systems, which will: research, develop, apply, improve and implement solutions, tools and methods of engineering and precision sciences, as well as methods and technologies of medical and

bioengineering to solve problems related to human health and quality of life; solve problems and problems of bioengineering for artificial creation or replacement of cells, tissues and organs of the human body, for artificial improvement and correction of their functions, development on this basis of laboratory analytical diagnostic technologies, tools and systems.

Test tasks for modular test work are added to the working curriculum.

Abstract is a current control measure, which involves solving a specific practical educational problem based on the theoretical scope of the discipline ***" Laboratory analytical equipment "*** using known and self-studied theoretical material for the design and construction of modern laboratory optoelectronic analytical devices for general purposes. Much of this work is graphic material, which is performed in accordance with current regulations and with the mandatory use of computer graphics, if defined by the task, and the use of modern software systems for designing biomedical equipment for laboratory analytical purposes. Abstract covers practical skills of modern tools and technologies of search, processing and analysis of information, research related to biomedical engineering interdisciplinary areas, critically analyze the results of their own research and the results of other researchers in the context of the whole complex of modern knowledge. Much of this work is graphic material, which is performed in accordance with applicable regulations and with the mandatory use of computer graphics, if defined by the task, and the use of modern software systems for designing laser and optoelectronic diagnostic devices for analytical purposes. Tests, as well as calculation work, may provide some illustrative material.

Approximate topics (name of individual task):

№1 Diagnostic complex for cardiological research. Schemes, features of work.
№2 Application of computers for the diagnosis of heart diseases. Modeling the work of the human heart.
№3 Methods of active thermography using hyperbaric oxygenation.
№4 Modern electrocardiography devices. Schemes, characteristics.
№5 Acoustic and holographic thermography. Schemes, characteristics.
№6 Modern methods of thermographic diagnostics. Schemes, characteristics.

Topics of individual tasks are added to the work program. (Appendix №2)

Extracurricular activities It is planned to study at least two field trips within the framework of studying the discipline - on the basis of modern medical medical rehabilitation centers, as well as participation in Exhibitions of modern medical instrument making, in particular **"Healthcare 202 and 2025",** etc.

Distance learning platform: For more effective communication in order to understand the structure of the discipline ***" Laboratory analytical equipment "*** and master the material e-mail, distance learning platform **"Sikorsky"** based on the **Moodle KPI-Telecom** system and service for online meetings **Zoom** are used, through which it is possible to : - simplify the placement and exchange of educational material; - provide students' feedback on learning objectives and content of the discipline; - evaluate students' learning tasks; - maintain the account of performance by students of the plan of academic discipline, the schedule of performance of educational tasks and their estimation.

6. Independent student work (ISW)

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

№ s/n	Names of topics and questions submitted for self-study and references to educational literature	Hours ISW
1	**Topic 1.2. Equipment for elementary laboratory procedures.** **Lectures – No. 2** **Literature [5,c.31-53;8,c.31-45;9,c.21-54;11,c.41-56].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[4,c.34-78;8,c.26-52;13,c.47-59].**	**10**
2	**Topic 1.3. Separation Methods.** **Lectures – No. 3** **Literature [8, c.19-36; 4, c.26-45; 6, c. 92-106; 13, c.19-27].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[8,c.34-68;9,c.56-97;16,c.47-105].**	**9**
3	**Topic 1.4. Optical methods in laboratory diagnostics.** **Lectures – No. 5,6** **Literature [5, c.75-98; 9, c.46-83; 13, c.67-122].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[1,c.34-67;17,c.67-109;19,c.34-79].**	**13**
4	**Topic 2.1. Biochemical research.** **Lectures – No. 8** **Literature [8, c.97-140;11, c.96-126; 21, c.76-105].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[6,c.45-77;16,c.34-67;19,c.34-92].**	**8**
5	**Topic 2.4. Molecular biological technologies.** **Lectures – No. 10Literature [6, c.55-78; 11, c.66-98; 20, c.71-129].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[5,c.44-76;8,c.28-49;12,c.56-87;18,c.75-107;18,c.61-84].**	**9**
6	**Topic 2.5. Microscopy.** **Lectures – No. 11Literature [1, c. 44-96; 3, c.55-97; 16, c.112-139; 17, c.105-123].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[4,c.44-67;8,c.106-118;11,c.74-109].**	**11**
7	**Topic 2.7. Automation of laboratory research** **Lectures – No. 14** **Literature [5, c.97-114; 8, c.106-123; 11, c.96-117].** **Tasks on ISW:** To study the material of the lecture, to prepare for a practical lesson on these sections, to study literary sources **[4,c.55-87;10,c.124-137;16,c.84-91].**	**6**
Total hours		**66**

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 represent 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 (presentation of practical work) must be practiced in the mentioned classes, provided that the task is scheduled for the current lesson, or in consultations.

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

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

Incentive points

Encouragement points	
Criterion	*Weight points*
Improving practical work	*1 points (for each practical work)*
Passing distance courses on topics that are agreed with teachers	*5 points*
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*
*Timely writing of **MTW***	*5 points*
*Timely delivery of the **test***	*10 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

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 **" Laboratory analytical equipment "** can be taught to most students with special educational needs, except for students with severe visual impairments that do not allow to perform tasks using personal computers, laptops and / or other technical means.*

Distance education

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

Distance education 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.

On 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	14	2	7	14
2.	Execution and test of practical works	24	2	12	24
3.	Execution and test of control works	27	3	9	27
4.	Modular control work (MCW)	15	15	1	15
5.	Abstract work (AW)	20	20	1	20

№ s/n	Control measure	%	Weight points	Number	Total
6.	Test work[1]	80	80	1	80
	Total				100

The applicant receives a positive credit score for the results of the semester, if he has a final rating for the semester of at least 60 points and has met the conditions of admission to the semester control, which are determined by the RSE (Rating System of Evaluation).

With applicants who have met all the conditions of admission to the test and have a rating of less than 60 points, as well as with those applicants who want to increase their rating, in the last scheduled lesson in the semester, the teacher conducts semester control in the form of test or interviews.

After performing the test, if the score for the test is higher than the rating, the applicant receives a score based on the results of the test.

If the grade for the test is lower than the rating, a "hard" RSE is used - the previous rating of the applicant (except for points for the semester individual task) is canceled and he receives a grade based on the results of the test. This option forms a responsible attitude of the applicant to the decision to perform the test, forces him to critically assess the level of his training and carefully prepare for the test.

***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	≥ 40 points
	Execution of practical work	PW № 1- 6	+	+
		PW № 7-12	-	+
	Express control works / test tasks	At least 4 of any lectures	+	-
		At least 8 of any lectures	-	+
	Modular control work	Estimated MCW	-	+
	Abstract work	Estimated AW	-	-

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 test		Criterion
1	Current rating	RD ≥ 42
2	Obtaining a positive assessment for the performed Abstract work	More than 8 points
3	All practical works are tested	More than 14 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".

[1] *Враховується в суму рейтингу разом з оцінкою за РГР у разі, якщо студент не набрав 60 балів за семестр або він хоче покращити свою оцінку.*

Optional conditions for admission to closure:

1. *Activity in practical classes.*
2. *Positive result of the first attestation and the second attestation.*
3. *Attending of 50% of lectures.*

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

Number points	*Assessment on the university scale*
100-95	*Perfect / 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*

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. Students have the right to challenge the results of the control measures, but it is obligatory to explain, with which criterion they do not agree according to the assessment letter and / or comments.

Additional information about the exam / test / interview:

The student has the right to improve their scores on the module test in the case of its timely writing in the scheduled class. Students are not allowed to use lecture notes or mobile devices during the test. It is allowed to use computer technology and educational and methodical support for practical classes.

9. Additional information on the discipline (educational component)

*The list of questions for preparation for **Abstract**, and also for preparation for credit is given in Appendix 2.*

Distance education 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).

The list of questions that are submitted for semester control for modular control work, as well as for preparation for the test:

1. Laser analyzers of human blood parameters. Schemes, characteristics.
2. Laser flow cytometry devices. Schemes, characteristics.
3. Application of lasers for the diagnosis of human blood diseases.
4. Laser therapeutic devices. Schemes, characteristics.

5. Application of UV lasers in medicine. Schemes, characteristics.
6. Application of IR lasers in medicine. Schemes, characteristics.
7. Effect of UV and IR radiation on biological objects.
8. Laser nephelometers. Principles of action, optical schemes, designs.
9. Application of lasers for irradiation of human blood. Schemes, characteristics.
10. Modern laser devices for measuring sugar content in human blood. Schemes, characteristics.
11. Modern laser scalpels on CO2 and solid-state lasers.
12. Fiber-optic medical endoscopes. Designs, characteristics.
13. Application of lasers in ophthalmology. Schemes, designs.
14. Application of lasers in oncology. Schemes, designs.
15. Application of lasers for therapy. Schemes, designs.
16. Application of lasers for diagnosis of diseases. Schemes, designs.
17. Application of lasers in surgery. Schemes, designs.
18. Application of lasers for treatment of human skin diseases, cosmetology.
19. Application of He-Ne lasers for treatment of cardiovascular diseases. Schemes, characteristics.
20. Application of laser spectrophotometers for diagnosis of human blood diseases. Schemes, characteristics.

.***Ability to enroll in certificates of distance learning courses:*** Distance education through online courses in the **Moodle** system on certain topics is an allowed subject to discuss with students. If a small number of students want to take an online course on a particular topic, studying the material with such courses is allowed, but students must complete all the tasks provided in the discipline (practical work, modular control work, calculation and graphic work). The list of distance courses is given on the website of the **Department of Biomedical Engineering KPI. Igor Sikorsky: http://bmi.fbmi.kpi.ua/non-formal-education.**

Appendices to the syllabus of the discipline " Laboratory analytical equipment "

Appendix 1. Program learning outcomes (extended form)

As a result of studying the discipline ***" Laboratory analytical equipment "*** students will be able to:

Learning outcomes		**Correspondence of learning outcomes to the competencies of the SVO [6]**	
		General Competence (soft skills)	**Special competence (professional)**
PRN 3	Manage complex activities or projects, be responsible for making engineering decisions in unpredictable conditions, conduct feasibility and safety assessments of projects (Reinforcement).	ZK 1 Ability to apply knowledge in practical situations. (Reinforcement).	FK 2 Ability to provide engineering and technical expertise in the planning, development, evaluation, and specification of medical equipment (Reinforcement).
PRN 7	Manage complex activities or projects, be responsible for making engineering decisions in	ZK 2 Knowledge and understanding of the	FK 7 Ability to plan, design, develop, install,

	unpredictable conditions, conduct feasibility and safety assessments of projects (Reinforcement).	subject area and understanding of professional activity (Reinforcement).	operate, maintain, service, control and coordinate the repair of devices, equipment and systems for prevention, diagnosis, treatment and rehabilitation used in hospitals and research institutes (Reinforcement).
PRN 10	Be able to plan, organize, direct and control medical and bioengineering systems and processes (Reinforcement).	ZK 4 Skills in using information and communication technologies (Reinforcement).	FK 2 Ability to provide engineering and technical expertise in the planning, development, evaluation, and specification of medical equipment (Reinforcement).
PRN 13	Be able to analyze signals transmitted from organs to devices and process diagnostic information (signals and images) (Reinforcement).	ZK 4 Skills in using information and communication technologies (Reinforcement).	Formulate logical conclusions and substantiated recommendations regarding the evaluation, operation and implementation of modern laboratory analytical equipment, medical and bioengineering tools and methods.
PRN 22	Knowledge of general principles and structure of complex biological systems, including the human body and its functions from the perspective of a systemic approach and their utilization in biomedical engineering, as well as basic methods and tools used for quantitative assessment of physiological system functioning (Reinforcement).	ZK 1 Ability to apply knowledge in practical situations. (Reinforcement).	FK 7 Ability to plan, design, develop, install, operate, maintain, service, control and coordinate the repair of devices, equipment and systems for prevention, diagnosis, treatment and rehabilitation used in hospitals and research institutes (Reinforcement).
PRN 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 (Reinforcement).	ZK 2 Knowledge and understanding of the subject area and understanding of professional activity (Reinforcement).	FK 2 Ability to provide engineering and technical expertise in the planning, development, evaluation, and specification of medical equipment (Reinforcement).

PRN 24	Being able to consider historical, social, environmental, ethical, legal, economic aspects, requirements of labor protection, industrial hygiene, and fire safety when forming technical solutions, taking into account the strengthening and preservation of personal and public health (Reinforcement).	ZK 13 The ability to preserve and multiply the moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technology and engineering, to use various types of physical activity for active recreation and leading a healthy lifestyle (Reinforcement).	FK 12 Ability to ensure and monitor compliance with safety and biomedical ethics when working with medical equipment (Reinforcement).

Appendix 2. Topics of individual tasks to check the level of learning material in the performance of Abstract:

The abstract reveals the following main issues:

1. Diagnostic complex for cardiological research. Schemes, features of work.
2. Use of computers for diagnosing heart diseases. Modeling the human heart.
3. Methods of active thermography using hyperbaric oxygenation.
4. Modern electrocardiography devices. Schemes, characteristics.
5. Acoustic and holographic thermography. Schemes, characteristics.
6. Modern methods of thermographic diagnostics. Schemes, characteristics.
7. Modern diagnostic complexes for laboratory and clinical research. Principle of operation. Schemes, characteristics.
8. Modern autoanalyzers. Features of work, schemes, characteristics.
9. Modern UV spectroscopy devices. Features of work, schemes, characteristics.
10. Modern fluorometers. Features of operation, diagrams, characteristics.
11. Modern optical laser cytometers. Features of operation, schemes, characteristics.
12. Laser systems for studying human blood parameters. Features of operation, schemes, characteristics.
13. Laser complexes for studying the optical characteristics of biological objects. Features of operation, schemes, characteristics.
14. Diagnostic equipment for recording human biopotentials. Features of operation, diagrams, characteristics.
15. Features of the operation of devices for electromyography and electrogastrography. Basic schemes, characteristics.

Work program of the discipline " Laboratory analytical equipment " (syllabus):

Compiled *by Associate Professor of Biomedical Engineering,* ***Mykola Bogomolov****.*

Approved by the Department of Biomedical Engineering (protocol № 16___ to 21.08.2024).

Approved by the Methodical Commission of the Faculty of Biomedical Engineering (protocol № 9 to 26.09.2024).[2]

[2] The syllabus template has been approved by the university's methodological council.