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

Department
biomedical engineering

HIGH-TECH SYSTEMS FOR DIAGNOSIS AND THERAPY

Working program of basic discipline (Silabus)

Requisites for basic discipline	
Level of higher education	***Second (master's)***
Branch of knowledge	*16 Chemical and Bioengineering*
Specialty	*163 Biomedical Engineering*
Educational program	*Medical Engineering*
Discipline status	*Mandatory discipline*
Form of study	*full-time / day / mixed / remote*
Year of preparation, semester	*1 course, autumn semester*
The scope of discipline	*5 ECTS credits / 150 hours*
Semester control / Control measures	*Test Work, Modular Test Work*
Lessons schedule	*According to the schedule on the site http://rozklad.kpi.ua/*
Language of instruction	*English*
Information about course leader / teachers	***Lecturer:*** *PHD, Associate Professor of Department of BME Sychyk Maryna Myhailivna, e-mail: marina.sychik@gmail.com, sychykmm@gmail.com, Telegram - https://t.me/Maryna_Sychyk* ***Practical:*** *PHD, Associate Professor of Department of BME Sychyk Maryna Myhailivna, e-mail: marina.sychik@gmail.com, sychykmm@gmail.com, Telegram - https://t.me/ Maryna_Sychyk*
Course placement	*Platform «Sikorsky» - course «High-tech systems for diagnosis and therapy Medical Microprocessor Systems»*

Curriculum of the discipline

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

The main purpose of the discipline "High-tech systems for diagnostics and therapy" is the formation of students' understanding of principles, instead of practical tips for development, testing and exploitation of medical technology for medical and health care

The discipline "High-tech systems for diagnosis and therapy" studies the fundamental-applied, medical-physical and bioengineering bases of technologies and equipment for research of physiological and pathological processes of the person, namely work of own conducting system of human heart, mechanisms of origin and support of arrhythmias, biophysical principles of action. radio frequency current on the biological tissue of the myocardium as a surgical treatment, electrophysiological protocols of stimulation and diagnosis of the effectiveness of the procedure.

Skills of the discipline "High-tech systems for diagnostics and therapy" is:

– formulating among students of building intelligence the principle and technical features of robots and apparatus and systems of piece rhythmic training, until the biological and technical laws of the functioning of the heart and tools are used in the future;

– to take part in the scientific and preliminaries of research in the development of engineering and scientific problems in the development of experimental models and prototypes of possession for diagnostic and therapeutic methods of treatment in arrhythmology and electology;

– to take the best fate with robots involved in the exploitation of medical possession, individual electrical stimulation, medical technology, keep records of key data in the course of electrical engineering of unnecessary results, as well as gotuvati operational services.

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

***GC 1** - Ability to abstract thinking, analysis and synthesis.*
***GC 2** - Ability to search, process and analyze information from various sources.*
***GC 3** - Ability to identify, formulate and solve problems.*
***GC 5** - Ability to work in an international context.*

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

***PC 1** - Ability to solve complex problems of biomedical engineering using the methods of mathematics, natural and engineering sciences.*
***PC 2** - Ability to develop a working hypothesis, plan and set experiments to test the hypothesis and achieve the engineering goal using appropriate technologies, technical means and tools.*
***PC 9** - Ability to create tools and methodologies of scientific activity, evaluation and implementation of the results of modern developments, solutions and achievements of engineering and exact sciences in medicine and biology.*
***PC 10** - Ability to design and practical use of microcomputer and microprocessor systems in medical and diagnostic information and measuring equipment.*

***The program learning outcomes after studying the discipline "Medical Microprocessor Systems" are** (OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):*

***PLO 1** - Understanding of fundamental-applied, medical-physical and bioengineering bases of technologies and equipment for research of physiological and pathological processes of the person.*
***PLO 2** - Understanding the principles of action of modern diagnostic equipment and display systems of biomedical information, the basis of appropriate software.*
***PLO 3** - Possession of modern methods of scientific research software, construction of adequate theoretical models and methods of their substantiation.*
***PLO 4** - Application of calculation methods and selection of classical and new designs of biomaterials, elements of devices and systems of medical appointment.*
***PLO 13** - Knowledge of a foreign language to an extent sufficient for general and professional communication.*
***PLO 20** - Evaluation of biological and technical aspects and consequences of interaction of engineering and bioengineering objects with biological systems, anticipation of their mutual influence, legal, deontological and moral and ethical consequences of use.*
***PLO 21** - Solving in practice the tasks of biomedical engineering with awareness of their own ethical and social responsibility in personal activities and / or in a team.*

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

The discipline "High-tech systems for diagnostics and therapy" belongs to the cycle of professional training and has an interdisciplinary nature. It integrates knowledge from other disciplines according to its subject: analog and digital circuitry, object-oriented programming, etc. For the structural and logical scheme of preparation of master's degree programs it is necessary to pay attention to other disciplines of general and professional training: "Biomedical information display

systems".

The obtained practical navigation and mastered theoretical knowledge during the study of the discipline "High-tech systems for diagnostics and therapy" can be used in the future during the involvement of educational elective disciplines: "Rehabilitation Engineering", "Prosthetics and artificial organs" and further practical work in the specialty.

3. The content of the discipline

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

Subject 1. History of the development of electrical stimulation and electrophysiology of the heart. Anatomy and physiology of the heart. Mechanisms of arrhythmias. Devices used in electrophysiological studies.

Subject 2. Methods of destruction of pathological conduction pathways. Radiofrequency ablation of pathological conduction pathways.

Subject 3. Electrophysiological studies and ablation of pathological foci in various types of cardiac arrhythmias.

Subject 4. Navigation systems used in electrophysiological research

Subject 5. Implanted artificial heart rate drivers. Implantable defibrillators.

Subject 6. Devices for synchronization and recovery of myocardial contractions. External defibrillators. Auxiliary diagnostic methods used in arrhythmology: MRI, CT, ultrasound.

4. Training materials and resources

Basic literature:

1. *Sychyk M.M. Catheter radiofrequency ablation of arrhythmogenic zones of the heart of increased efficiency and safety / MM Sychyk // National Technical University of Ukraine, Kyiv Polytechnic Institute named after Igor Sikorsky, dissertation. to obtain Ph.D. - Kyiv. -2007. - 225 p.*
2. *Ardashev A.V. Clinical arrhythmology // Medical practice. - Moscow. - 2009. - 1220 p.*
3. *Chazov E.I. Guide to heart rhythm disorders / E.I. Chazov, SP Galitsin // GEOTAR-Media. - Moscow. - 2008. - 416 p.*
4. *Doronin A.V. Treatment of tachyarrhythmias of the heart by catheter destruction // Kiev. - 2008. - 96 p.*
5. *Issa Z. Clinical arrhythmology and electrophysiology: a companion to Braunwald's heart disease – 2nd Edition / Z. Issa, M. Miller, D.P. Zipes. // Saunders Elsevier. – Philadelphia. – 2012. – 726 p.*
6. *Schmitt C. Catheter Ablation of Cardiac Arrhythmias: A Practical Approach / C. Schmitt, I. Deisenhofer, B. Zrenner // Springer. – München. – 2006. – 296 p.*
7. *Wilber D.J. Catheter Ablation of Cardiac Arrhythmias: Basic Concepts and Clinical Applications / D.J. Wilber, D.L. Packer, W.G. Stevenson // Blackwell/Futura. – New York. – 2008. – 375 p.*
8. *Shenasa M. Cardiac Mapping, 4th Edition / M. Shenasa, G. Hindricks, M. Borggrefe, G. Breithardt, M.E. Josephson, D.P. Zipe // Wiley-Blackwell. – 2012. – 966 p.*
9. *Huang S.K.S. Catheter Ablation of Cardiac Arrhythmias (Second Edition) / S.K.S. Huang, M.A. Wood // Saunders Elsevier. – Philadelphia. – 2013. – 650 p.*
10. *Murgatroyd F.D. Handbook of Cardiac Electrophysiology. A Practical Guide to Invasive EP Studies and Catheter Ablation / F.D. Murgatroyd, A.D. Krahn, G.J. Klein, R.K. Yee, A.C. Skanes // ReMEDICA Publishing. – London. – 2002. – 239 p.*

Additional literature:

1. *. Electronic catalog of KPI library: https://ela.kpi.ua/simple-search?location=%2F&query=сичик+м.м.&rpp=10&sort_by=score&order=desc*

2. *Electronic catalog of educational materials Medtronic Academy: https://www.medtronicacademy.com*
3. *Electronic catalog of educational materials Abbott: https://www.abbott.com/careers/students.html*

Educational content

5. Methods of mastering the discipline (educational component)

№ s/n	Subject	Program learning outcomes	The main tasks	
			Control measure	Deadline
1.	History of the development of electrical stimulation and electrophysiology of the heart. Anatomy and physiology of the heart. Mechanisms of arrhythmias. Devices used in electrophysiological studies.	PLO 1, 2, 3, 4, 13, 20, 21	Practical work 1; Practical work 2	1-3 th week
2.	Methods of destruction of pathological conduction pathways. Radiofrequency ablation of pathological conduction pathways.	PLO 1, 2, 3, 4, 13, 20, 21	Practical work 3; Practical work 4;	4 th week
			Practical work 5; Practical work 6	5 th week
3.	Electrophysiological studies and ablation of pathological foci in various types of cardiac arrhythmias.	PLO 1, 2, 3, 4, 13, 20, 21	Practical work 7; Practical work 8;	7 th week
			Laboratory work 1; Laboratory work 2	8 th week
			Laboratory work 3; Laboratory work 4	9 th week
			Practical work 9; Practical work 10	10 th week
4.	Navigation systems used in electrophysiological research	PLO 1, 2, 3, 4, 13, 20, 21	Laboratory work 5;	11 th week
			Laboratory work 6; Laboratory work 7;	12 th week
			Practical work 11; Practical work 12	13 th week
5.	Implanted artificial heart rate drivers. Implantable defibrillators.	PLO 1, 2, 3, 4, 13, 20, 21	Laboratory work 8;	14 th week
			Practical work 13; Practical work 14	15 th week
6.	Devices for synchronization and recovery of myocardial contractions. External defibrillators. Auxiliary diagnostic methods used in arrhythmology: MRI, CT, ultrasound.	PLO 1, 2, 3, 4, 13, 20, 21	Laboratory work 9;	16 th week
			Practical work 15; Practical work 16;	17 th week
			Practical work 17; Practical work 18	18 th week

6. Independent student work

One of the main types of semester control during the mastering of the discipline is the defense of practical classes on the topics of the discipline and schedule.

Policy and control

7. Policy of academic discipline (educational component)

Attending classes

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

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

Control measures missed

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

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

Violation of deadlines and incentive points

Encouragement points		*Penalty points **	
Criterion	*Weight points*	*Criterion*	*Weight points*
Improving practical work	*1 points (for each practical work)*	*Untimely implementation and test of practical work*	*From -0.5 points to -5 points (depending on the delivery date)*
Passing distance courses on topics that are agreed with teachers	*5 points*	*Untimely execution and test of calculation and graphic work*	*From -2 points to -20 points (depending on the construction period)*
Registration of scientific work for participation in the competition of student scientific works	*10 points*		
Writing abstracts, articles, participation in international, national and / or other events or competitions on the subject of the discipline	*5 points*		

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

Academic integrity

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

Norms of ethical behavior

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

Procedure for appealing the results of control measures

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

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

Inclusive education

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

Distance learning

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

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

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

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

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

Learning a foreign language

Teaching in English is carried out only for foreign students.

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

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

Evaluation system (current control):

№ s/n	Control measure	%	Weight points	Number	Total
1.	Execution and test of practical works	32	2	16	32
2.	Execution and test of laboratory works	27	3	9	27
3.	Modular control work (MCW)	12	12	1	12
4.	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		≥ 15 points	≥ 30 points
	Execution practical work	PW № 1- 8	+	+
		PW № 9-12	-	+
	Execution of laboratory works	LW № 1- 2	+	+
		LW № 3- 9	-	+
	Modular control work	Estimated MCW	-	+

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 ≥ 40
2	All practical works are tested	More than 24 points
3	All laboratory works are tested	More than 12 points
4	Writing Modular control work	More than 4 points

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

Optional conditions for admission to closure:

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

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

Number points	Assessment on the university scale
100-95	Perfectly / Відмінно
94-85	Very good / Дуже добре
84-75	Good / Добре
74-65	Satisfactorily / Задовільно
64-60	Enough / Достатньо

Less 60	*Unsatisfactorily / Незадовільно*
Admission conditions are not met	*Not allowed / Не допущено*

9. Additional information on the discipline (educational component)

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

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

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

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

Work program of the discipline (syllabus):

Compiled by *PHD, Associate Professor of Department of BME Sychyk Maryna Myhailivna.*

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

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

Appendix 1 to the syllabus of the discipline

"High-tech systems for diagnostics and therapy"

The list of questions for preparation for modular control work,

And also for preparation for test

Block 1. Anatomy of the heart and main vessels. Heart rhythm disorders. Tachycardia.

1) Electrophysiology. Phenomenon. Concept. Science. Practical implementation in arrhythmology. Signal registration and electrical stimulation.
2) Anatomy of the heart. Trunk vessels. Vascular access to cardiac chambers for catheter insertion (for electrophysiological examination and radiofrequency ablation). (drawing with symbols).
3) Own conductive system of the heart (figure). The main functions (characteristics of the myocardium) of the heart: automatism, conductivity, excitability, contraction, refractoriness. Comparison of cardiogram and endogram in different areas of the heart during electrophysiological examination.
4) Electrocardiogram (definition, essence of a technique, assignment, drawing and the short decoding of the main complexes: P, QRS, T).
5) Tachycardia: the main types (drawing of the heart with the location and description of each arrhythmia, and the place where you want to apply radiofrequency ablation). Isthmus-dependent atrial flutter. Left atrial fibrillation. Ventricular arrhythmia. Ventricular fibrillation. Ventricular tachycardia. Atrial ectopic tachycardia. Atrial fibrillation. Atrioventricular nodal tachycardia. Atrial re-entry tachycardia. Wolf-Parkinson-White syndrome.
6) Mechanisms of occurrence and maintenance of tachycardias: abnormal automatism, trigger activity and the mechanism of re-entry of electrical excitation (re-entry) (with drawings on the heart for example).

Block 2. Catheter radiofrequency ablation in the treatment of tachycardia.

1) Biophysics of radiofrequency ablation of myocardial tissues for the treatment of tachycardia: resistive and conductive heating.
2) Electrical diagram of radiofrequency ablation (nodes). Characteristics of nodes. Possible problems.
3) The main electrical terms that define the RFA procedure: current (what?), Voltage, impedance (?), Power.
4) Technical factors that affect the damage: power, temperature (?), Exposure time, electrodes (which and how)), contact with the tissue, etc.
5) Radiofrequency generator for catheter ablation. Generator operation modes: power control mode, temperature control mode.
6) Catheter electrodes for radiofrequency ablation. Selection of catheters for RF for different areas of the heart and the size of the destruction. (Description and figures).
7) Complications of catheter RCA.

Block 3. Electrophysiological study for the diagnosis of tachyarrhythmias.

1) Electrophysiological station, system components, equipment.
2) Types of diagnostic electrode catheters for electrophysiological research. Features. Appointment.
3) Types of heart endogram registration: monopolar and bipolar.

4) Signal processing and filtering in electrophysiological study.
5) Diagnostic electrophysiological examination of the heart. Appointment. When performing. What they study.
6) Protocols of pacing at invasive electrophysiological research of conducting system of heart.
7) Protocols of constant stimulation at invasive electrophysiological research. When applied. An example of an arrhythmia.
8) Protocols of programmed stimulation with extrastimulus in invasive electrophysiological study. An example of an arrhythmia.
9) Protocols of incremental stimulation in invasive electrophysiological examination. An example of an arrhythmia.

Block 4. Navigation systems for electroanatomical mapping.

1) Types of navigation systems, structure (manufacturers, types, technical parameters).
2) Principles of construction of anatomical maps for the system Ensite Velosity NavX, St. Jude medical).
3) Principles of construction of anatomical maps for the system Carto, Biosense Webster.
4) Construction of activation cards. Significance for the diagnosis of arrhythmia.
5) Construction of potential maps. Significance for the diagnosis of arrhythmia.