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

Department
biomedical engineering

QUANTITATIVE PHYSIOLOGY

Working program of educational discipline (Syllabus)

Requisites of the Course	
Cycle of Higher Education	***First (bachelor's)***
Branch of knowledge	*16 Chemical and Bioengineering*
Specialty	*163 Biomedical Engineering*
Educational program	*Medical Engineering*
Course status	*Mandatory*
Mode of study	*full-time / day / mixed / remote*
Year of study/Semester	*2nd year (autumn / fall semester)*
ECTS workload	*4.5 ECTS credits / 135 hours*
Testing and Assessment	*Final Test, Module Test, Home Control Work*
Course schedule	*According to the schedule on the site http://rozklad.kpi.ua/*
Language of instruction	*English*
Information about course supervisor / teachers	***Lecturer:*** *Candidate of Biological Sciences, Associate Professor of BME Svitlana Vovianko, e-mail: sivovianko@gmail.com, Telegram - https://t.me/vovianko_svitlana* ***Practical:*** *Candidate of Biological Sciences, Associate Professor of BME Svitlana Vovianko, e-mail: sivovianko@gmail.com, Telegram - https://t.me/vovianko_svitlana*
Course placement	*Platform «Sikorsky» - course «Quantitative Physiology» (rv30hp)*

Distribution of hours				
Semester	**Lectures**	**Practical**	**Laboratory**	**Self-study**
Autumn/fall semester	*28*	*26*	*18*	*63*

Outline of the Course

1. Course description, goals, objectives, and learning outcomes

The main purpose of the Course "Quantitative Physiology" is to form students' ability to apply methods and means of quantitative evaluation of the functioning of physiological systems in practical engineering activities.

Course "Quantitative Physiology" provides the engineering student with a basic understanding of physiological principles with an emphasis on quantitative aspects. The first is about knowing the numerical value for the ranges of crucial aspects of physiology, such as the flows or forces within the body. The second is about discovering the relations between physiological parameters.

The Course integrates labs and problem sets to provide opportunities for practice and includes clinical applications relevant to the biomedical engineering student. Understanding the relations between physiological parameters, knowledge of ranges is a necessary basis for creating biotechnical means of maintaining or replacing vital functions of the body.

Skills are required to study the Course:

- *Knowledge of the basics of anatomy, physiology, human biochemistry, mathematics..*

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

GC 1 *- Ability to apply knowledge in practical situations.*
GC 2 *- Knowledge and understanding of the subject area and understanding of professional activity.*
GC 3 *– Ability to communicate in the state language both orally and in writing.*
GC 4 *– Skills in the use of information and communication technologies.*
GC 5 *– Ability to perform research at the appropriate level.*
GC 6 *– Ability to search, process and analyze information from various sources.*
GC 7 *– Ability to generate new ideas (creativity).*
GC 8 *– Ability to make well-grounded decisions.*
GC 9 *– Ability to communicate with representatives of other professional groups of different levels (with experts from other fields of knowledge / types of economic activity).*
GC 10 *– Safe activities skills.*

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

PC 4 *– Ability to provide technical and functional characteristics of systems and tools used in medicine and biology (in prevention, diagnosis, treatment and rehabilitation).*
PC 5 *– Ability to apply physical, chemical, biological and mathematical methods in the analysis, modeling of the functioning of living organisms and biotechnical systems.*
PC 8 *– Ability to perfect research and observations on the interaction of biological, natural and artificial systems (prostheses, artificial organs, etc.).*
PC 13 *– Ability to provide and monitor compliance with safety and biomedical ethics when working with medical 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 processes of a human body.*
PLO 5 *– Knowledge of research methods and techniques used in the design of medical equipment.*
PLO 10 *– Knowledge of the basic physical and physicochemical patterns of biological objects functioning.*
PLO 14 *– Possession of tools for experimental research (medical devices, biomaterials for medical purposes).*
PLO 17 *– Knowledge of general information about the human body and its functions from the standpoint of a systems approach and their use in biomedical engineering.*
PLO 21 *– Knowledge of the basic methods and tools used to quantify the functioning of physiological systems.*
PLO 23 *– Knowledge of universal principles of complex biological systems structure, including the human body.*
PLO 24 *– Knowledge of the basic methods and tools used to quantify the functioning of physiological systems.*
PLO 29 *– Professional communication with healthcare professionals in the state and foreign languages (English or one of the other official EU languages) and understanding of their requirements for biomedical products and services.*
PLO 32 *– Understanding of theoretical and practical approaches to creation and application of artificial biological and biotechnical objects and materials of medical appointment.*
PLO 43 *– The use of methods and means of quantitative evaluation of the functioning of physiological systems in practical engineering.*

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

The course "Quantitative Physiology" belongs to the cycle of professional training and has an interdisciplinary nature. According to the structural and logical scheme of preparation of bachelor's degree program the course "Quantitative Physiology" is closely related to the following courses of professional training: "Human Anatomy and Physiology", "Biochemistry", "Biophysics", "Biomaterials and biocompatibility". It is immediately preceded by the course "Human Anatomy and Physiology".

3. Course Overview

The main parts and subjects that will be considered in the process of studying the course:

Unit1. Quantitative characteristics of electromagnetic processes in the body

Subject1.1. Origin of electrical force, potential, capacitance and current in living organisms. Information transfer by electrical excitation.

Subject1.2. Propagation of excitation in nerve and muscle fibers.

Subject1.3. Quantitative electrophysiology of the brain

Subject1.4. The cardiac quantitative electrophysiology

Unit2. Quantitative characteristics of mass transfer in the human body. Flows and forces.

Subject2.1. Blood and the circulatory system: cardiac work, hemodynamics and microcirculation.

Subject2.2. Respiratory physiology: the mechanics of breathing, lung volumes, airway resistance, alveolar gas exchange and gas transport.

Subject2.3. Fluid and electrolyte balance: body fluid compartments, fluid volumes, glomerular filtration, and clearance.

Subject2.4. Applying the principles of systems approach in the study and modeling of biological and engineering systems.

4. Coursebooks and teaching resources

Basic:

1. *Hall J.E., Hall M.E. Guyton and Hall Textbook of Medical Physiology. 14th Edition. — Elsevier, 2020. — 1028 p.*
2. *Professor Dave Explains. Anatomy & Physiology. Educational resource: 26 videos // https://www.youtube.com/watch?v=6_BKeoFXOdo&list=PLybg94GvOJ9HVbNobTmFnOxXRn1dIpffc*
3. *Feher J.J. Quantitative Human Physiology: An Introduction. 2nd Edition. — Academic Press, 2016. — 1008 p.*

Supplementary:

1. *Burton R.F. Biomedical Calculations: Principles and Practice. — Chichester, England: John Wiley & Sons Ltd, 2008. — xvi + 294 p.*

Educational content

5. Methods of mastering the discipline (educational component)

№ s/n	*Subject*	*Program learning outcomes*	*The main tasks*	
			Control measure	*Deadline*
1.	*Origin of electrical force, potential, capacitance and current in living organisms. Information transfer by electrical excitation*	*PLO 1 PLO 10*	*Practical work 1*	*3rd week*

2.	Propagation of excitation in nerve and muscle fibers	PLO 1 PLO 10	Practical work 2,3	4th week
3.	Quantitative electrophysiology of the brain	PLO 5 PLO 10 PLO 14 PLO 17 PLO 24	Practical work 4	5th week
4.	Module Test, Unit1	PLO 1 PLO 10 PLO 24 PLO 29	Module Test writing	5th week
5.	The cardiac quantitative electrophysiology	PLO 5 PLO 10 PLO 14 PLO 17 PLO 21 PLO 24	Practical work 5, 6 Laboratory work 1	7th week
6.	Blood and the circulatory system: cardiac work, hemodynamics and microcirculation	PLO 5 PLO 10 PLO 14 PLO 17 PLO 21 PLO 24	Practical work 7, 8, 9 Laboratory work 2, 3, 4	8th – 10th week
7.	Respiratory physiology: the mechanics of breathing, lung volumes, airway resistance, alveolar gas exchange and gas transport	PLO 5 PLO 10 PLO 14 PLO 17 PLO 21 PLO 24	Practical work 10, 11 Laboratory work 5, 6	11th – 12th week
8.	Fluid and electrolyte balance: body fluid compartments, fluid volumes, glomerular filtration, and clearance	PLO 10 PLO 17 PLO 21 PLO 24 PLO 32 PLO 43	Practical work 12	13th week
9.	Applying the principles of systems approach in the study and modelling of biological and engineering systems	PLO 17 PLO 23 PLO 24 PLO 43	-	-
10.	Module Test, Unit2	PLO 10 PLO 23 PLO 24 PLO 29 PLO 32	Module Test writing	13th week
11.	Home Control Work	PLO 10 PLO 17 PLO 21 PLO 24 PLO 32 PLO 43	Registration and submission of a work	13th – 14th week
12.	Final Test	PLO 10 PLO 17 PLO 21 PLO 24 PLO 32 PLO 43	Final Test Pass	17th week

6. Self-study

Preparing for the classes is carried out in accordance with the plan of the course with the links to the MOODLE platform.

One of the main types of semester control during the mastering of the discipline "Quantitative Physiology" is the Home Control Work. Home Control Work is performed in accordance with the requirements, within the period specified by the teacher.

The main purpose of the Home Control Work is to solve a practical problem using the material learned in lectures and independently, and practical skills acquired in practical work.

Home test consists of 10 assignments from different subjects of the Course:

-3 problems – from Unit1 by Subject1.1. Origin of electrical force, potential, capacitance and current in living organisms. Information transfer by electrical excitation, Subject1.2. Propagation of excitation in nerve and muscle tissues.

-7 problems – from Unit1 by Subject2.1. Blood and the circulatory system: cardiac work, hemodynamics and microcirculation, Subject2.2. Respiratory physiology: the mechanics of breathing, lung volumes, airway resistance, alveolar gas exchange and gas transport, Subject2.3. Fluid and electrolyte balance: body fluid compartments, fluid volumes, glomerular filtration, and clearance

The list of problems is set for each student according to the option.

The title page of the Home Control Work should have the following content: the name of the university; name of the faculty; name of department; name of specialty, name of educational-professional program, name of academic course; option of Home Control Work; surname and name of the student, year of study, code of the academic group, year.

Deadline for Home Control Work submission for examination: 13-14th week of study.

Home Control Work must meet the requirements of academic integrity. In case of academic dishonesty, the work is canceled and not checked.

Policy and control

7. Attendance policy

Attending classes

Attendance at lectures is optional. Attending practical classes is desirable. All works and activities are aimed at the students' compliance with the assessment rating requirements. A significant part of a student rating is formed through active participation in activities in practical classes. Therefore, skipping a practical class does not allow a student to get points in the semester rating. General assessment takes place according to a scheme of the agreed grading system. Expected learning outcomes, control measures and deadlines are announced to students in the first practical class.

Control measures missed

Missed control measures (defense of practical work) can be worked out during the next classes, (provided that the task is scheduled for the current classes), or in consultations.

Missed labs can be worked out during the next labs, (provided that the task is scheduled for the current classes), or in consultations.

Skipped express tests cannot be completed.

Skipped Module Test can be worked out in consultations.

Violation of deadlines, penalty points and rewarding points

Rewarding points		*Penalty points**	
Criterion	*Weight points*	*Criterion*	*Weight points*
Practical or laboratory work improvement	*1 point (for each work)*	*Untimely implementation of a practical work*	*From -0.5 points to -5 points (depending on the delivery date)*
Online courses completed on the topics that are agreed with the teacher	*5 points*	*Untimely implementation of a laboratory work*	*From -0.5 points to -5 points (depending on the delivery date)*
Registration of scientific work for participation in the competition of student scientific works	*10 points*	*Untimely implementation of a Module Test*	*From -0.5 points to -5 points (depending on the delivery date)*
Writing of abstracts, articles, participation in international, national and / or other events or competitions on the subject of the Course	*From 5 points to +10 points*	*Untimely implementation of a Home Control Work*	*From -2 points to -5 points (depending on the delivery date)*

** 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 course "Quantitative Physiology" can be taught to the most of students with special educational needs.

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 and defense of a Home Control Work is carried out during self-study work of students in a remote mode (with a possibility of consultation with the teacher through e-mail, social networks).

Teaching in 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. Monitoring and grading policy

Grading system (current control):

№ s/n	Control measure	%	Weight points	Number	Total
1.	Express tests	8	2	4	8
2.	Execution and defense of a practical works	24	2	12	24
3.	Performance and defense of a laboratory works	30	5	6	30
4.	Module Test (MT),Unit1	12	12	1	12
5.	Module Test (MT),Unit2	16	16	1	16
6.	Home Control Work (HCW)	10	10	1	10
7.	Final Test[1]	90	90	1	90
	Total				100

In the final practical class of the course, students will add their rewarding points, if there are any, to the performance score, and /or subtract their penalty points if there are any, from the performance score, and in case it is in total higher than 60 points, they may either get their Pass or take the Final Test to improve their grade. If the grade for the Final Test is higher than the final performance grade, the student receives the grade based on the results of this Test. If the grade for the Test is lower, the final performance grade is cancelled and the student receives a grade based on the results of the Test.

Students whose final performance grade is 30-60 points have to take the Final Test in order to complete the course.

Students whose score is below 30 did not meet the requirements of the course and are not allowed to take the Final 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.

[1] *Taken into account in the amount of the rating together with the grade for HCW in case the student has not scored 60 points per semester or he wants to improve his grade.*

Criterion			The first CC	The second CC
Deadline of calendar controls			8th week	14th week
Requirements to obtain a positive calendar control	Current grade		≥ 24 points	≥ 40 points
	Execution of practical work	PW No.1-4	+	+
		PW No.5-8	-	+
	Execution of laboratory works	LW No.1		
		LW No.3-6		
	Module Test	Estimated MT1	+	+
		Estimated MT2	-	+
	Home Control Work	Estimated HCW	-	-

In the case of a plagiarism or an academic poor quality during training the control measure is not credited.

Semester certification of students

Mandatory requirements for the admission to the Final Test		Criterion
1	Current grade	RD ≥ 40
2	All laboratory works are completed	More than 0 points
3	Home Control Work is completed	More than 6 points

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

Optional requirements for the admission to the Final Test:

1. *Active work during practical classes.*
2. *Positive result of the first and the second calendar control.*
3. *Attending of lectures.*

The final performance score or the results of the Final Test are adopted by university grading system as follows:

Number points	Assessment on the university scale
100-95	Excellent / Відмінно
94-85	Very good / Дуже добре
84-75	Good / Добре
74-65	Satisfactory / Задовільно
64-60	Satisfactory / Достатньо
Less 60	Unsatisfactory / Незадовільно
The course requirements are not met	Not allowed / Не допущено

9. Additional information on the course (educational component)

Module Test (MT), which is planned for the course and is designed for a total of two academic hours, is conducted in two practical classes: for the Unit1 – in the 5th week and for the Unit2 – in the 13th week.

The list of questions for preparation for Module Test, 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 tests, practical work).

Work program of the course (syllabus):

is developed by *Associate Professor of BME, Candidate of Biological Sciences, Svitlana Vovianko.*

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 course
"Quantitative Physiology"

The list of questions for preparation for the Module Test,

And also for preparation for the Final Test

1. *What is homeostasis? Why is it called a dynamic equilibrium?*
2. *Give an example of a positive feedback in living organisms. Indicate the variable, the sensor, the integrator and the effector.*
3. *Give an example of a negative feedback in living organisms. Indicate the variable, the sensor, the integrator and the effector.*
4. *Describe the general structure and function of the plasma membrane*
5. *Specify the ionic composition of intracellular fluid and extracellular fluid. Indicate the differences in their composition.*
6. *Distinguish between active and passive transport. Give an example of an active and passive transport.*
7. *Distinguish between primary and secondary active transport. Give an example of a primary and secondary active transport mechanism.*
8. *What is a resting potential? What is the total current across the membrane at the resting membrane potential?*
9. *What is an action potential? Why does the membrane potential become positive during the action potential?*
10. *Explain spontaneous rhythmicity in cardiac tissue.*
11. *Explain an excitation-contraction coupling in cardiac muscle.*
12. *Describe the components of the cardiovascular system and their function.*
13. *Give the definition of the stroke volume and ejection fraction.*
14. *Draw a pressure – volume curve for the left ventricle ("Volume-Pressure Diagram"). Label the region of ventricular filling during diastole, the period of isovolumetric contraction, the period of ejection of blood, and the period of isovolumetric relaxation.*
15. *Explain the laminar and turbulent blood flow in the vessels.*
16. *Write Poiseuille's law for laminar flow through long narrow tubes. What parameters does the vessel resistance depend on?*
17. *Describe the basic hemodynamic parameters. How are they related? Write a formula*
18. *What cardiovascular function parameters are controlled in the living organism?*
19. *Identify and calculate the driving "force" that moves an air into and out of the lungs.*
20. *Draw a dynamic pressure – volume curve for the lungs of a healthy person. Label the period of inspiration, and the period of expiration.*
21. *Draw a spirometer trace and label the tidal volume TV, inspiratory reserve volume IRV, expiratory reserve volume ERV, residual volume RV, the vital capacity VC, and the total lung capacity TLC. Identify them. Indicate which of them cannot be measured by spirometry alone.*
22. *Define the anatomic dead space. How does it affect the mixing of gases in the lungs and alveolar ventilation?*
23. *List the sequential barriers to diffusion that are present between air and blood in the lungs. Why does O_2 move from the alveoli to the venous blood and CO_2 moves from the venous blood to the alveoli?*
24. *Write the factors that modify hemoglobin transport of oxygen. How they modify it?*
25. *Write the Starling equation for the forces that produce the glomerular ultrafiltrate. What is the main force favoring formation of the glomerular ultrafiltrate? What are the main forces opposing the formation of the glomerular ultrafiltrate?*
26. *Explain what is meant by countercurrent multiplier in kidneys.*
27. *Give the definition of the clearance. How to determine the clearance for any substance?*