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

Department of
Biomedical Engineering

Biomedical mechanics

Working program of basic discipline (Syllabus)

Details of the 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	*Mandatory discipline*
Form of study	*full-time / day / mixed / remote*
Year of preparation, semester	*3rd year, autumn semester*
The scope of discipline	*4 ECTS credits (36 hours - lectures, 36 hours - practical, 48 hours - independent work))*
Semester control / Control measures	*Credit / Test Work, Modular Test Work, Home controle Work*
Lessons schedule	*According to the schedule on the site http://rozklad.kpi.ua/*
Language of instruction	*English*
Information about course leader / teachers	Lecturer: *Ph.D., docentt of the department of Biosafety and Human Health , PhD Associate Professor Antonova-Rafi Yuliia Valeriivna* *antonova-rafi@ukr.net* *0675063994* Practical: *Ph.D., docentt of the department of Biosafety and Human Health , PhD Associate Professor Antonova-Rafi Yuliia Valeriivna* *antonova-rafi@ukr.net* *0675063994*
Course placement	Platform «Sikorsky» - course «Biomedical mechanics» (https://do.ipo.kpi.ua/course/view.php?id=3476)

Distribution of hours

Semester	Lectures	Practical	Independent Work
autumn semester	*36*	*36*	*48*

Curriculum of the discipline

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

The main purpose of the discipline "Biomedical mechanics" is to form students' ability to solve complex specialized problems and practical problems from biomechanics.The overall purpose of this course is to introduce the fundamental principles of mechanics applied to the: study of biological systems.

Discipline "Biomedical mechanics" is required for all graduates in the Bioengineering Program and is the starting point for coursework in biomechanics. Students should be familiar with the concepts covered in this course enrollment in mechanics , Biosolid Mechanics.

Introduction to the basics of biology for an engineer. Mechanisms and biomechanics of DNA, proteins, cells, connective tissue, skeletal muscle tissue and cardiovascular tissue, principles of integration of living systems, structural and functional relations, methods used for studybiology and medicine and tissue engineering.

Skills are required to study the discipline:

To study the discipline requires skills: knowledge formed during the study of basic disciplines in 1-2 courses.

1. Compose the equation of equilibrium of bodies;
2. Compose differential equations of motion of points and mechanical systems;
3. Apply dynamics theorems to determine the kinematic characteristics of motion;
4. Determine the internal force factors using the method of sections.

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.

GC 6 -Ability to search, process and analyze information from various sources.

GC 8 – Ability to make well-grounded decisions.

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

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 6 - Ability to effectively use tools and methods for analysis, design, calculation and testing in the development of biomedical products and services.

PC 8 *- Ability to perfect research and observations on the interaction of biological, natural and artificial systems (prostheses, artificial organs, etc.).*

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 12 – Ability to understand the technical and functional characteristics of systems, methods and procedures used in prevention, diagnosis and therapy

PC 14 - Ability to perfect experiments according to specified technical and medical methods, perform computer processing, analysis and synthesis of the results

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 5 *- Application of methods and tools for designing computer networks.*

PLO 6 *- Possession of methods of designing digital microprocessor and biotechnical systems for medical purposes.*

PLO 10 *- Knowledge of the basic physical and physicochemical patterns of biological objects functioning.*

PLO 17 *- Analysis and solution of complex medical-engineering and bioengineering problems with the use of mathematical methods and information technologies.*

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 .*

The program of disciplin

1. Description of academic disciplines , its purpose, the subject will examine e ting and learning outcomes

Following completion of this course, students will be able to:

(1) use both index and direct notation

(2) understand transformation of coordinate systems and how to solve problems in rigid body kinematics

(3) apply finite deformation kinematics to analyze deformation and strain

(4) understand the concept of stress

(5) apply linear elasticity to analyze stresses and strains in materials under homogeneous deformation

(6) derive and interpret the equations of motion for deformable bodies

(7) interpret differences in the material behavior of biological materials in terms of their constituents and organization

(8) perform analysis of viscoelastic systems based on discrete element models

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

The discipline "Biomedical Mechanics" has an interdisciplinary nature, which integrates knowledge from other disciplines.

According to the structural and logical scheme of the training program, the discipline is provided by the following disciplines and credit modules: "Materials Science and Structural Materials", "Quantitative Physiology", "Biophysics", "Mechanics", "Human Anatomy and Physiology-2". Fundamentals of human anatomy and physiology .

The acquired practical skills and acquired theoretical knowledge during the study of the discipline can be used in the future during the mastering of the disciplines " Measuring transducers and sensors ", "Biothermodynamics and mass transfer".

3. The content of the discipline

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

Section 1 . . **General issues of biomedical mechanics**

Subject 1.1. Introduction to the basics of biomedical mechanics .

Subject 1.2. Biomechanics of the musculoskeletal system .

Subject 1.3. Biomechanics of locomotions .

Section 2. Medical biomechanics

Subject 2.1 Biomechanics of hemodynamics .

Subject 2.2. Biomechanics of the digestive system .

Subject 2.3. Biomechanics of human analyzers.

Subject 2.4. Biomechanics of the human musculoskeletal system .

4. Training materials and resources

Basic literature

1. Begun PI, Shukeilo Yu.A. Biomechanics: A textbook for universities. - СПб .: Политехника, 2000. - 463 с.

2. Herman I. Physics of the human body. Per. from English: Scientific publication. - Dolgoprudny: Publishing House "Intellect", 2011. - 992 p .: http://brb.to/texts/other/i49DlMSFkaEocgOM7ZCcOcM-fizika-organizma-cheloveka.html

3. Dubrovsky V I, Fedorova V N Biomechanics: A textbook for universities. - M .: VLADOS-PRESS, 2003. - 672 p .: http://nn-tennis.ru/File/Biomech.pdf

4. Lebed O O, Garashchenko V I, Grigus IM Biological and medical mechanics. Teaching. Manual. - Rivne: NUVGP, 2016. - 186 p.

5. Тарасова, Л.Д. Biomedical mechanics. Collection of tasks for home control works [Electronic resource]: textbook. way. for applicants for a bachelor's degree in the educational program "Medical Engineering" specialty 163 "Biomedical Engineering" / L.D. Тарасова; KPI them. Igor Sikorsky. - Electronic text data (1 file: 1.36 MB). - Kyiv: KPI named after Igor Sikorsky, 2020. - 45 p. - Access: https://ela.kpi.ua/handle/123456789/34678 .

Additional literature:

1. Begun PI, Afonin PN Modeling in biomechanics. 2004. 390 p. ISBN 5-06-004798-9.

2. Grigorieva LI, Tomilin YA Fundamentals of biophysics and biomechanics: textbook. way. - Mykolaiv: BSU Publishing House named after Petra Mogili, 2011. - 300 p.

3. Kizilova NN Synopsis of lectures on the course "Biomechanics". - Kharkiv: KhTURE Publishing House. - 1999. - 108 p.

4. Laputin AM etc. According to the general edition of A.M. Laputin. Biomechanics of sport: A textbook. - Kyiv: Olympic Literature, 2005. - 320 p.

5. Milnikov OV Strength of Materials. - Ternopil: TNTU Publishing House, 2010. - 257 p.

6. Methodical instructions for practical classes on the course "Biomechanics" for students majoring in "Biotechnical and medical devices and systems" / Uporyad. NN Kizilova. - Kharkiv: KhTURE, 1999. –52 p.

7. Methodical instructions for home control work on the credit module "Biomedical Mechanics" for students in the direction of training 6.051402 "Biomedical Engineering" [Electronic resource] / NTUU "KPI"; structure. L.D. Tarasova, - Electronic text data (1 file: 190 Kbytes). - Kyiv: NTUU "KPI", 2014. - 17 p. - Access: http://ela.kpi.ua/handle/123456789/8962 .

8. Methodical instructions for performance of complex control work from the credit module "Biomedical mechanics" for students of directions of preparation 6.051402 "Biomedical engineering", 6.050101 "Computer sciences", 6.051003 "Instrument making" [Electronic resource] / NTUU "KPI"; structure. L. D. Tarasova,. - Electronic text data (1 file: 681 KB). - Kyiv: NTUU "KPI", 2014. - 20 p. - Access: http://ela.kpi.ua/handle/123456789/9960 .

9. Methodical instructions for performing a comprehensive test in the discipline "Fundamentals of Biomedical Engineering - 1. Biothermodynamics and mass transfer" for students in the direction of training 6.051402 - "Biomedical Engineering" [Electronic resource] / NTUU "KPI"; structure. V.B. Maksymenko, L. D. Tarasova, M.M. Sichik. - Electronic text data (1 file: 69.0 KB). - Kyiv: NTUU "KPI", 2014. - 20 p. - Access: http://ela.kpi.ua/handle/123456789/11288 .

10. Methodical instructions for conducting practical classes on the subject "Fundamentals of Biomedical Engineering - 1. Biothermodynamics and Mass Transfer" for students in the direction of training 6.051402 - "Biomedical Engineering" [Electronic resource] / NTUU "KPI"; structure. V.B. Maksymenko, L. D. Tarasova, M.M. Sichik. - Electronic text data (1 file: 252 KB). - Kyiv: NTUU "KPI", 2015. - 43 p. Access: http://ela.kpi.ua/handle/123456789/11289 .

11. Remizov AN, Maksina AG, Potapenko A.Ya. Medical and biological physics: Textbook. for universities. - M .: Дрофа, 2003. - 560 с.

12. Patent search on the topic "Hip arthroplasty" .

Educational content

5. Methods of mastering the discipline (educational component)

And nformatsiya (sections, topics s) all training sessions

Subjects	Program learning outcomes	The main tasks	
		Control measure	Deadline
Section 1. General issues of biomedical mechanics			
Subject 1.1. Introduction to the basics of biomedical mechanics .	PLO 1	Practical work 1 Practical work 2 Practical work 3 Practical work 4	1st week Week 2 Week 3 4th week
Subject 1.2. Biomechanics of the musculoskeletal system .	PLO 5	Practical work 5 Practical work 6	5th week 6th week
Subject 1.3. Biomechanics of locomotions .	PLO 6	Practical work 7 Practical work 8	7th week 8th week
Section 2. Medical biomechanics			
Subject 2.1 Biomechanics of hemodynamics .	PLO 10	Practical work 9 Practical work 10	9th week 10th week
Subject 2.2. Biomechanics of the digestive system .	PLO 17	Practical work 11	1 1st week
Subject 2.3. Biomechanics of human analyzers.	PLO 23	Practical work 12	1 2nd week
Modular control work		Writing MCW / testing	1 2nd week
Subject 2.4. Biomechanics of the human musculoskeletal system.	PLO 21, PLO 5	Practical work 1 3 Practical work 1 4 Practical work 1 5 Practical work 1 6	1 3rd week 1 4th week 1 5th week 1 6th week

Home control work	PLO 6, PLO 23	Submission for verification. Presentation and defense of DKR	15-16th week . 17th week
TEST			18th week

6. Independent student work

(preparation for classroom classes, calculations based on primary data obtained in laboratory classes, problem solving, abstract writing, calculation work, homework, etc.) :

№	Types of independent work	Hours
11	Working theory, considered second in class	9
2.	Solution tasks and payments for theme Tiko practical work	16
3.	Preparation for modular control work / testing	3
4.	Doing homework	16
5.	Preparation for the test	4
Together		**48**

One of the main types of semester control during the mastering of the discipline "Biomedical mechanics" is home control work. Homework is performed in accordance with the requirements, within the period specified by the teacher.

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

Approximate subject of home control work

The purpose of HCW is independent performance by the student of a certain practical work on the basis of the mastered theoretical material.

DKR covers the following topics:

1. Statics of body parts.
2. Mechanical properties of biological tissues.
3. Biomechanics of the musculoskeletal system.
4. Instrumental research methods.

HCW structure

DKR includes: title page, introduction, table of contents, main part, conclusions, list of sources used.

The title page should have information that is presented in the following sequence: name of the university; name of the faculty; name of department; name of academic discipline; the name of the control measure; level of higher education; code and name of the specialty; the name of the educational and professional program; task variant, surname and name of the student, course, number of the academic group; Name of the head; the result of protection; year.

The introduction states the purpose of the HCW.

The main part includes solving problems with the required illustrative material. The solution of tasks should be clear, specific, accompanied by the necessary explanations with reference to sources of information. The reference should be indicated by the ordinal number according to the list of used sources in square brackets, for example, "... in the collection of tasks

The conclusion indicates the experience gained in performing each task of the HCW.

The list of used sources (not less than 5 sources) is made out according to operating rules. If the information is taken from the Internet, you need, as for ordinary literature, specify the author, the title of the article, and then provide the site address on the Internet.

Registration of HCW

ROC must be printed th on a standard sheet of format 4 with the following requirements: left field - 30 mm, right - 15 mm, top - 20 mm, bottom -20 mm; Times New Roman font size 14 pt; line spacing - 1.5; indentation of the red line - 1.25; text alignment - width.

Requirements for the amount of DCR are not put forward. The volume should be such as to fully reveal the essence of the topic and contain all the necessary structural elements. A minimum of 10 and a maximum of 25 pages is recommended.

Each structural element of the content of the work begins with a new page. The names of the structural elements should be placed in the center of the line without a dot at the end, without underlining, separated from the text by three line spacing. The transfer of syllables in words is not used. Figures and tables must have headings and numbering consistent with the section number.

Evaluation of HCW

HCW is assessed by the following criteria: completeness and depth of disclosure of the topic; correctness of calculations; possession of theoretical material; availability of illustrations (diagrams, tables, figures, diagrams, etc.); clarity of references to sources of information; quality of registration of DKR; substantiation of the student's own opinion in the form of a conclusion.

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

Deadline for submitting homework for review: 10 days before the test session. Protection of DKR is planned to be carried out on 1 7th week.

Policy and control

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.

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.

Violation of deadlines and incentive points

Encouragement points		Penalty points	
Criterion	Weight score	Criterion	Weight score
Active participation in oral interviews at lectures	+1 point	Violation of deadlines for practical work (for each such work)	- 1 point
Writing abstracts, articles, participation in international, national and / or other events or competitions on the subject of the discipline	+ 3 points	Untimely writing of MCR / testing	-2 points
		Late submission of homework	- 6 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 "Kyiv Polytechnic Institute named after Igor Sikorsky". Details: https://kpi.ua/code

Norms of ethical behavior

Norms of ethical behavior of students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute named after Igor Sikorsky". Details: https://kpi.ua/code

Procedure for appealing the results of control measures

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

The student has the right to appeal the results of control measures in accordance with the Regulations on appeals in KPI. Igor Sikorsky (order №НОН / 128/2021 from 20.05.2021) https://osvita.kpi.ua/node/182

Inclusive education

The discipline can be taught to most students with special educational needs, except for people with severe visual impairments who are not allowed to perform tasks using personal computers, laptops and / or other technical means.

Learning a foreign language

Teach ting English made only for foreign students on the curriculum of the department for foreign students.

Distance Learning

Distance learning is through e platform ystantsiyn th training "Sikorsky". Execution of practical works , modular control work, home control work is carried out during independent

work of students in a remote mode with a possibility of consultation with the teacher through e-mail, platforms in ZOOM , social networks.

8. Types of control and rating system Est yuvannya learning outcomes (RSO)

Types of control and scores for each control element

№ s / n	Control measure	%	Weight score	Number	Total
1.	Practical work	40	2.5	1 6	40
2.	MCR / testing	2 0	2 0	1	2 0
3.	Home control work	40	40	1	40
	Total				100

The results are announced to each student individually in the presence or remotely - in the Moodle system or by e-mail. In case of detection of plagiarism or establishment of non-independent performance of work, points for the control measure are not credited.

Current control

Practical work

№ s / n	Evaluation criterion	Scores
1.	Complete answer (at least 90% of the required information)	2.5-2.3
2.	Sufficiently complete answer or complete answer with minor inaccuracies (not less than 75% of the required information)	2.2-1.9
3.	Incomplete answer and minor errors (at least 60% of required information)	1.8-1.5
4.	The answer is missing or incorrect	0

Modular control work / testing

№ s / n	Evaluation criterion	Scores
1.	Complete answer (at least 90% of the required information)	2 0 - 18
2.	Sufficiently complete answer or complete answer with minor inaccuracies (not less than 75% of the required information)	17 -1 5
3.	Incomplete answer and minor errors (at least 60% of required information)	1 4 -1 2
4.	The answer is missing or incorrect	0

Home control work

№ s / n	Evaluation criterion	Scores
1.	Complete and timely execution of the task, error-free solution of the problem, the material is presented with knowledge of theoretical material, logically, consistently, with clarity (not less than 90% of the	4 0- 36

	required information)	
2.	The task is not complete enough or with some inaccuracies. Visual material is not used to the full (at least 75% of the required information).	35 - 30
3.	The task is not fully disclosed, partially or with some shortcomings. Visual material is insufficient (at least 60% of the required information).	2 9 - 24
4.	The task is incomplete and (or) with fundamental errors. Visual material is insufficient (less than 50% of the required information). There is no ownership of the material	0

Calendar control

Intermediate attestation of students (hereinafter - attestation) is a calendar boundary control. The purpose of the certification is to improve the quality of student learning and monitor the implementation of the schedule of the educational process by students.

Criterion			The first certification	Another certification
Term of certification			8th week	14th week
Conditions for obtaining certification	Current rating		≥ 10.5 points	≥ 2 2 , 5 points
	Performing practical work	№ № 1-7	+	-
		№ № 8-14	-	+
	Performing MCR / testing	MCR / testing	-	+
	Performing homework	Home control work	-	-

Semester control

Conditions of admission to semester control

Mandatory condition for admission to the test	Criterion
Current rating , including:	RD ≥ 60
- in the implementation of MCR / testing	not less than 60% of the maximum score
- with the protection of home control work	not less than 60% of the maximum score

Credit is a type of semester control in which the student's mastery of educational material is assessed on the basis of the results of current control. To receive a "machine" test you must have a rating of at least 60 points.

Students who have a rating of less than 60 points at the end of the semester, as well as those who want to increase their rating, in the last scheduled class pass the semester control in the form of a test.

The test is conducted orally, is evaluated at 60 points and consists of four questions / tasks, each of which is evaluated at 15 points.

To assess what a student receives for scoring quiz, added amount of points for the home control work and this rating grade is final.

№ s / n	Criteria for evaluating each question / task of the test	Number of points for each question / task
1.	Complete answer, not less than 90% of the required information, performed in accordance with the requirements for the level of "skills" (complete, error-free solution of the problem)	15 -13.5
2.	Sufficiently complete answer, at least 75% of the required information, performed in accordance with the requirements for the level of "skills" or there are minor inaccuracies (complete solution of the problem with minor inaccuracies)	13-11.5
3.	Incomplete answer, at least 60% of the required information, which is performed in accordance with the requirements for the "stereotypical" level and there are some errors (the task is performed with certain shortcomings)	11- 9
4.	The answer does not meet the conditions for "satisfactory"	0

When performing a test, students are not allowed to use textbooks, abstracts, reference books, phones, smartphones, PCs, etc.

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 *Associate Professor of Technical Sciences, Ph.D , docentt of the department of Biosafety and Human Health ,* Antonova-Rafi Yuliia Valeriivna

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

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