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

Department
biomedical engineering

# SOFTWARE ENGINEERING IN BIOMEDICAL RESEARCH

## Working program of basic discipline (Silabus)

| Requisites for basic discipline | |
|---|---|
| **Level of higher education** | ***First (bachelor's)*** |
| **Branch of knowledge** | *16 Chemical engineering and Bioengineering* |
| **Specialty** | *163 Biomedical Engineering* |
| **Educational program** | *Medical Engineering* |
| **Discipline status** | *Elective educational components* |
| **Form of study** | *full-time / day / mixed / remote* |
| **Year of preparation, semester** | *3th course, autumn semester* |
| **The scope of discipline** | *4 ECTS credits / 120 hours* |
| **Semester control / Control measures** | *Final Test, Module Test Work, Calculation and Graphic Work* |
| **Lessons schedule** | *According to the schedule on the site http://rozklad.kpi.ua/* |
| **Language of instruction** | *English* |
| **Information about course leader / teachers** | ***Lecturer:*** *Doctor of Technical Sciences, Associate Professor, Head Department of BME Shlykov Vladyslav Valentynovych, e-mail: v.shlykov@kpi.ua, Telegram: https://t.me/vshlykov*<br>***Practical:*** *Doctor of Technical Sciences, Associate Professor, Head Department of BME Shlykov Vladyslav Valentynovych, e-mail: v.shlykov@kpi.ua, Zoom: 759 0245 5108, code 202202* |
| **Course placement** | *Platform «Sikorsky» - course «Software Engineering in Biomedical Research»* |

**Distribution of hours**

| Semester | Lectures | Practical | Laboratory | Independent Work |
|---|---|---|---|---|
| ***autumn semester*** | *18* | *36* | *0* | *66* |

**Curriculum of the discipline**

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

*The main goal of the academic discipline "Software Engineering in Biomedical Research" is to develop students' ability to solve specialized tasks and practical problems of software engineering in biomedical research, which involves the use of software tools for implementing statistical methods, signal filtering, image processing, neural network design, and interaction of application programs with microcontrollers based on specialized libraries in the Python programming language.*

*The academic discipline "Software Engineering in Biomedical Research" studies the use of software tools for processing the results of biomedical research by implementing special statistical methods, signal filtering, image processing, neural network design, and interaction of application programs with microcontrollers.*

*Skills are required to study the discipline:*

1. *Software tools for implementing data processing methods (specialized Python libraries);*
2. *Software tools for creating applications (PyCharm environment, Python language);*
3. *Software tools for interacting with C/C++ programs with Arduino UNO microcontrollers.*

***General competencies** (OPP was put into effect by the Rector's Order NON/434/2024 of 10.06.2024 p.):*

***ZK 1 -** Ability to apply knowledge in practical situations.*
***ЗК 4** - Skills in using information and communication technologies.*
***ZK 5** - Ability to conduct research at an appropriate level.*

***Special (professional) competencies** (OPP was put into effect by the Rector's Order NON/434/2024 of 10.06.2024 p.):*

***FK 1** - Ability to apply engineering software packages for research, analysis, processing, and presentation of results, as well as for automated design of medical devices and systems.*
***FK 3** - Ability to study and apply new methods and tools for analysis, modeling, design, and optimization of medical devices and systems.*
***FK 6** - Ability to effectively use tools and methods for analysis, design, calculation, and testing in the development of biomedical products and services.*
***FK 11** - Ability to develop, plan, and conduct experiments using specified technical and biomedical techniques, applying mathematical methods in the analysis and modeling of the functioning of living organisms, systems, and processes in biology and medicine, computer processing, analysis, and synthesis of the obtained results.*

***The program learning outcomes after studying the discipline "Microprocessor Engineering" are** (OPP was put into effect by the Rector's Order NON/434/2024 of 10.06.2024 p.):*

***PRN 5** - Be able to use databases, mathematical and software tools for data processing and computer modeling of biotechnical systems.*
***PRN 8** - Understand theoretical and practical approaches to the creation and management of medical equipment and medical technology.*
***PRN 13** - Be able to analyze signals transmitted from organs to devices and process diagnostic information (signals and images).*
***PRN 20** - Knowledge and application of research methods in biomedical engineering, methods and tools for organizing and processing experimental data, statistical methods for modeling and simulating processes and systems of physical and biological nature, modern programming technologies and supporting tools, methods for designing digital and microprocessor-based medical systems.*

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

*The academic discipline "Software Engineering in Biomedical Research" belongs to the cycle of professional training and is interdisciplinary in nature. It integrates, in accordance with its subject, knowledge from other academic disciplines: higher mathematics, engineering and computer graphics, object-oriented programming, etc. According to the structural and logical scheme of the bachelor's program, the discipline is closely related to other disciplines of general and professional training: "Higher Mathematics", "Fundamentals of Discrete Mathematics", "Engineering and Computer Graphics", "Object-Oriented Programming", "Electrical Engineering and Electronics".*

*The practical skills obtained and theoretical knowledge acquired during the study of the academic discipline "Software Engineering in Biomedical Research" are recommended to be used in the future when mastering the elective academic disciplines: "Biomedical Devices, Apparatus and Complexes", "Analog and Digital Circuitry", "Microprocessor technic".*

## 3. The content of the discipline

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

***Section 1. Graphical capabilities of Python modules.***

*Subject 1.1. Two-dimensional graphs with the matplotlib module.*

*Subject 1.2. Three-dimensional graphs with the matplotlib module.*

***Section 2. Algorithms for calculating elementary functions.***

*Subject 2.1. Algebraic Calculations.*

*Subject 2.2. Graphical Functions of the mpmath module.*

***Section 3. Numerical methods in Python.***

*Subject 3.1. Approximating functions using the SciPy module.*

*Subject 3.2. Interpolating functions using the SciPy module.*

***Section 4. Scientific computing in Python.***

*Subject 4.1. Calculating Integrals Using the SciPy module.*

*Subject 4.2. Ordinary differential equations and systems.*

***Section 5. Statistical analysis in Python.***

*Subject 5.1. Quantitative data analysis in descriptive statistics.*

*Subject 5.2. Correlation analysis using the NumPy module.*

***Section 6. Designing Neural Networks in Python.***

*Subject 6.1. Implementing Activation Functions Using NumPy and SciPy modules.*

*Subject 6.2. Backpropagation Neural Network with weight matrix between layers.*

***Section 7. Image processing in Python.***

*Subject 7.1. Using OpenCV 3 computer vision in Python.*

*Subject 7.2. Smoothing and denoising images using the cv2 module.*

***Section 8. Signal processing and visualization in Python.***

*Subject 8.1. Compressing and decompressing WAV audio format using the Wave module.*

*Subject 8.2. Filtering and processing biosignals using the SciPy module.*

***Section 9. Interaction of a Python application program with Arduino microcontrollers.***

*Subject 9.1. Firmata protocol on Arduino UNO v3.*

*Subject 9.2. PySerial module operation on Python 3.9.*

*Subject 9.3. PySerial and Firmata interaction when visualizing sensor data.*

## 4. Training materials and resources

***Basic literature:***


*1. Мінаков С.М. Інформатика. Лабораторний практикум: навч. посіб. для здобувачів ступеня бакалавра за освіт. програмою «Інжиніринг зварювання, лазерних та споріднених технологій» спец. 131 «Прикладна механіка» / С.М. Мінаков, А.В. Чорний, А.С. Мінаков, І.М. Вдовіченко, Д.М. Вдовіченко; КПІ ім. Ігоря Сікорського. – Київ: КПІ ім. Ігоря Сікорського, 2023. – 313 с. – https://ela.kpi.ua/bitstreams/2a58b808-f7d1-4f31-879f-bcac040e7df6/download*

*2. Івановський О.А, Парненко В.С. Інформатика. Програмування на Python: навч. посіб. для здобувачів ступеня бакалавра за освіт. програмою «Конструювання та дизайн машин» спец. 131«Прикладна механіка» / О.А. Івановський, В.С. Парненко; Київ: КПІ ім. Ігоря Сікорського, 2023. – 232 с. – https://ela.kpi.ua/bitstreams/c26afa66-3722-4411-a4e0-f8b7988dbc2d/download*

*3. Новотарський М.А. Основи програмування алгоритмічною мовою Python: навч. посіб. для студ. освітньої програми «Комп'ютерні системи та мережі» спеціальності 123 «Комп'ютерна інженерія» / М.А. Новотарський. – Київ: КПІ ім. Ігоря Сікорського, 2022. – 701с. – https://ela.kpi.ua/bitstreams/969a46b8-e5cb-4513-8b8a-1e6e267e0306/download*

*4. Татарчук Д.Д. Об'єктно-орієнтоване програмування мовою Python: Конспект лекцій: навч. посіб. для студ. спеціальності 153 «Мікро- та наносистемна техніка» освітньої програми «Мікро- та наноелектроніка» / КПІ ім. Ігоря Сікорського; уклад.: Д. Д. Татарчук, Ю. В. Діденко. – Київ: КПІ ім. Ігоря Сікорського, 2021. – 129 с. – https://ela.kpi.ua/bitstreams/672a2e48-69df-42c1-8c2c-e7eeb4ebea8c/download*

*5. Горобець О.Ю. Мова python: для інженерних та наукових задач: підруч. для здобувачів ступеня бакалавра за спеціальністю 162 «Біотехнології та біоінженерія», магістра за спеціальністю за спеціальністю 162 «Біотехнології та біоінженерія», бакалавра за спеціальністю 104 «Фізика та астрономія» та магістра за спеціальністю 104 «Фізика та астрономія» / О. Ю. Горобець, С. В. Горобець, К. Ю. Хахно ; КПІ ім. Ігоря Сікорського. – 1-ше вид. – Київ: КПІ ім. Ігоря Сікорського, 2024. – 277 с. – https://ela.kpi.ua/bitstreams/f67fb7d1-d4ac-4317-8007-e1774606ed49/download*

*6. Креневич А.П. Python у прикладах і задачах. Частина 2. Об'єктно-орієнтоване програмування. Навчальний посібник – К.: ВПЦ "Київський Університет", 2020. – 152 с. – https://www.mechmat.univ.kiev.ua/wp-content/uploads/2021/01/python-u-prykladakh-i-zadachakh.-ch2-oop.pdf*

*7. Лавер В.О., Левчук О.М. Обробка зображень: навч.-метод. посіб. / В.О. Лавер, О.М. Левчук. – Ужгород: ПП «АУТДОР - ШАРК», 2021. – 51 с. – https://dspace.uzhnu.edu.ua/jspui/bitstream/lib/35667/1/Обробка%20зображень%202021.pdf*

*8. Попов А.Ю. Теорія сигналів. Лабораторний практикум: навч. посіб. для здобувачів ступеня бакалавра зі спеціальності 153 Мікро- та наносистемна техніка / Уклад.: А.О. Попов, К.О. Іванько, Г.С. Порєва; – Київ: КПІ ім. Ігоря Сікорського, 2022. – 121 с. – https://ela.kpi.ua/bitstreams/46faa968-71d2-4cf8-833e-e2cac33985be/download*

*9. Попов А.О. Аналіз та розпізнавання біомедичних сигналів: навчальний посібник для здобувачів ступеня магістра зі спеціальності 153 Мікро- та наносистемна техніка / Уклад.: А.О. Попов, К.О. Іванько; – Київ: КПІ ім. Ігоря Сікорського, 2022. – 67 с. – https://ela.kpi.ua/bitstreams/2dfcf5cb-cdf0-4748-bce2-2d2851746d75/download*

*10. Куссуль Н.М. Аналіз даних. Лабораторний практикум: навч. посіб. для студ. спеціальності 113 Прикладна математика / Н.М. Куссуль, А.Ю. Шелестов, С.А. Тарасенко, Г.О. Яйлимова; КПІ ім. Ігоря Сікорського. – Київ: КПІ ім. Ігоря Сікорського, 2022. – 28 с. – https://ela.kpi.ua/bitstreams/213801fb-45e7-4fd2-80ac-ed2b17c41e3a/download*

*11. Анісімов А.В. Програмування числових методів мовою Python: підруч. / А.В. Анісімов, А.Ю. Дорошенко, С.Д. Погорілий, Я. Ю. Дорогий, Є.В. Глушко; за ред. А.В. Анісімова. – К.: Видавничо-поліграфічний центр "Київський університет", 2014. – 640 с. – https://ist.kpi.ua/wp-content/uploads/2017/05/Дорогий_Підручник.pdf*

*12. Копей В.Б. Мова програмування Python для інженерів і науковців: навчальний посібник для виконання курсових і магістерських робіт під час підготовки фахівців першого (бакалаврського) та другого (магістерського) рівнів освіти за спеціальністю 131 Прикладна механіка / В.Б. Копей. – Івано-Франківськ: ІФНТУНГ, 2019. – 272 с. – https://github.com/vkopey*

*13. Шликов В.В. Програмна інженерія в біомедичних дослідженнях. Практикум: навч. посіб. для здобувачів ступеня бакалавра за освіт. програмою «Медична інженерія» спец. 163 Біомедична інженерія / КПІ ім. Ігоря Сікорського ; уклад.: В. В. Шликов, Н. О. Бритва. – Київ: КПІ ім. Ігоря Сікорського, 2025. – 163 с. – https://ela.kpi.ua/handle/123456789/73045*

*14. Варфоломєєв А.Ю. Методичні вказівки до виконання лабораторних робіт з дисципліни «Системи технічного зору» для студентів спеціальностей 7.05090201, 8.05090201 «Радіоелектронні апарати та засоби» / Уклад.: А.Ю. Варфоломєєв, В.Г. Дзюба. – К.: НТУУ «КПІ», 2015. – 83 с. – https://ela.kpi.ua/bitstreams/437e3015-ac79-4781-aa92-9a884c1b288a/download*

*15. Парфенюк О.І. Технології об'єктно-орієнтованого та Web-програмування: методичні вказівки для здобувачів вищої освіти першого (бакалаврського) рівня зі спеціальності 151 Автоматизація та комп'ютерно-інтегровані технології / Парфенюк О.І., Присяжнюк О.В., Сафоник А.П. – Рівне: НУВГП, 2019. – 91 с. – http://ep3.nuwm.edu.ua/16687/1/04-03-201%20%281%29.pdf*

***Additional literature:***


*1. Сіциліцин Ю.О., Шаров С.В. Прикладне програмне забезпечення (Python): лабораторний практикум. Запоріжжя: Таврійський державний агротехнологічний університет ім. Дмитра Моторного, 2024. – 147 с. – http://www.tsatu.edu.ua/kn/wp-content/uploads/sites/16/ppz.pdf*

*2. Таірова М.С. Мова програмування Python для наукових обчислень. Частина 1. Інтегроване середовище Anaconda; Основи бібліотек NumPy: навч. посіб. з дисципліни «Програмні засоби наукових обчислень» / М.С. Таірова, З.Ю. Журавльова. – Одеса: Одес. нац. ун-т ім. І.І. Мечникова, 2022. – 260 с. – https://dspace.onu.edu.ua/bitstreams/d329a4f3-b5f0-4bc3-ae86-edb9a393c88f/download*

*3. Цибко Г.Ю., Горошко Ю.В., Костюченко А.О. Програмування у Python. Практичний курс: навчальний посібник. Чернігів: ФОП Баликіна С.М., 2022. – 180 с. – https://files.znu.edu.ua/files/Bibliobooks/Inshi72/0052382.pdf*

*4. David Steinberg. Modern Statistics A Computer-Based Approach with Python / Peter Gedeck, Ron S. Kenett, Shelemyahu Zacks, Tel Aviv, Israel: Tel Aviv University, 2022. – 438 p.*

*5. Michiel de Hoon. Statistics for Python / Michiel de Hoon, New York: Columbia University, 2010. – 25 c.*

*6. Nikhil Ketkar. Deep Learning with Python: Learn Best Practices of Deep Learning Models with PyTorch, Second Edition / Nikhil Ketkar and Jojo Moolayil, New York: SSBM Finance Inc., 2021. – 306 p.*

*7. Nour Eddine ALAA and Ismail Zine El Abidne. Introduction to Image Processing with Python / Nour Eddine ALAA and Ismail Zine El Abidne, Cadi Ayyad University: LAMAI Laboratory FST Marrakech, 2021. – 77 p.*

*8. Roger R Labbe Jr. Filters in Python / Kalman and Bayesian, Mountain View: California Inc., 2020. – 262 p.*

*9. Joe Minichino. Learning OpenCV 3 Computer Vision with Python, Second Edition / Joe Minichino and Joseph Howse, Open Source: Packt Publishing, 2015. – 242 p.*

*10. Pratik Desai. Python Programming for Arduino / Pratik Desai, Open Source: Packt Publishing, 2010. – 576 p.*


***Electronic resources:***

1. *Approximating functions using the SciPy module: https://pythonpip.ru/examples/podgonka-krivoy-v-python-s-pomoschyu-biblioteki-scipy*
2. *Interpolating functions using the SciPy module: https://coderlessons.com/tutorials/python-technologies/uchitsia-stsipi/scipy-interpolirovat*
3. *Calculating integrals using the SciPy module: https://russianblogs.com/article/59071487246*
4. *Ordinary differential equations and systems (SciPy): https://habr.com/ru/post/418139*
5. *Implementing activation functions using NumPy and SciPy modules: https://python-course.eu/machine-learning/running-neural-network-with-python.php*
6. *Backpropagation neural network with weight matrix between layers: https://python-course.eu/machine-learning/training-neural-network-with-python.php*

**Educational content**

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

| *№ s/n* | *Subject* | *Program learning outcomes* | *The main tasks* | |
|---|---|---|---|---|
| | | | *Control measure* | *Deadline* |
| *1.* | *Graphical capabilities of Python modules:*<br>*Part 1. Two-dimensional plots with the matplotlib module.*<br>*Part 2. Three-dimensional plots with the matplotlib module.* | *PRN 5*<br>*PRN 13* | *Practical work 1* | *3rd week* |

| | | | | |
|---|---|---|---|---|
| | *Part 3. Signal analysis using Python's graphical capabilities.* | | | |
| *2.* | *Algorithms for calculating elementary functions:*<br>*Part 1. Algebraic Calculations.*<br>*Part 2. Graphical Functions of the mpmath module.*<br>*Part 3. Practical algorithms for creating and managing medical equipment.* | *PRN 5*<br>*PRN 8* | *Practical work 2* | *4th week* |
| *3.* | *Numerical methods in Python:*<br>*Part 1. Approximating functions using the SciPy module.*<br>*Part 2. Interpolating functions using the SciPy module.*<br>*Part 3. Python software for data processing and computer modeling.* | *PRN 5* | *Practical work 3* | *5th week* |
| *4.* | *Scientific computing in Python:*<br>*Part 1. Calculating Integrals Using the SciPy module.*<br>*Part 2. Ordinary differential equations and systems.*<br>*Part 3. Modern programming technologies and scientific computing tools.* | *PRN 5*<br>*PRN 20* | *Practical work 4* | *6th week* |
| *5.* | *Statistical analysis in Python:*<br>*Part 1. Quantitative data analysis in descriptive statistics.*<br>*Part 2. Correlation analysis using the NumPy module.*<br>*Part 3. Statistical processing methods for modeling and simulation of processes and systems of physical and biological nature.* | *PRN 5*<br>*PRN 20* | *Practical work 5* | *7th week* |
| *6.* | *Designing Neural Networks in Python:*<br>*Part 1. Implementing Activation Functions Using NumPy and SciPy modules.*<br>*Part 2. Backpropagation Neural Network with weight matrix between layers.*<br>*Part 3. Practical approaches to using neural networks to create and control medical equipment.* | *PRN 5*<br>*PRN 8* | *Practical work 5* | *8th week* |
| *7.* | *Image processing in Python:*<br>*Part 1. Using OpenCV 3 computer vision in Python.*<br>*Part 2. Smoothing and denoising images using the cv2 module.*<br>*Part 3. Using image processing methods to study biomedical engineering objects.* | *PRN 5*<br>*PRN 20* | *Practical work 6* | *9th week* |
| *8.* | *Signal processing and visualization in Python:*<br>*Part 1. Compressing and decompressing WAV audio format using the Wave module.* | *PRN 5*<br>*PRN 20* | *Practical work 6* | *10th week* |

| | | | | |
|---|---|---|---|---|
| | *Part 2. Filtering and processing biosignals using the SciPy module.*<br>*Part 3. Application of signal visualization methods for simulation of processes and systems of physical and biological nature.* | | | |
| *9.* | *Interaction of a Python application program with Arduino microcontrollers:*<br>*Part 1. Firmata protocol on Arduino UNO v3.*<br>*Part 2. PySerial module operation on Python 3.9. PySerial and Firmata interaction when visualizing sensor data.*<br>*Part 3. Python design methods for digital and microprocessor medical systems.* | *PRN 5*<br>*PRN 20* | *Practical work 7* | *11th week* |
| *10.* | *Modular control work* | | *Practical work 8* | *12th week* |
| *11.* | *Calculation and graphic work* | *PRN 5*<br>*PRN 8*<br>*PRN 13*<br>*PRN 20* | *Registration and submission of work* | *13th week* |
| *12.* | *Final Test* | | *Practical work 9* | *14th week* |

***Practical works***

*The main tasks of the cycle of practical works: consolidation in practice of the main provisions of the academic discipline "Software Engineering in Biomedical Research" by performing specially formulated tasks and real software solutions for biomedical equipment units, which are actually designed in the master's theses of students. The practical class includes conducting a control of knowledge, skills and abilities, solving problems of designing microprocessor systems with their discussion, solving control tasks, their verification and evaluation.*

*The grades received by the student for individual practical classes are entered into the journal of the study group and are taken into account when determining the final grade (rating) for this academic discipline.*

| *№ s/n* | *Practical work topic* | *Duration in hours* |
|---|---|---|
| *1* | *2D and 3D plots with the Matplotlib module* | *4* |
| *2* | *Algebraic Calculations in Python* | *4* |
| *3* | *Approximate and Interpolate functions with the SciPy module* | *4* |
| *4* | *Calculate Integrals with the SciPy module* | *4* |
| | *Ordinary differential equations and systems* | |
| *5* | *Correlation analysis with the NumPy module* | *4* |
| | *Backpropagation Neural Network with a weight matrix between layers* | |
| *6* | *Using OpenCV 3 computer vision in Python* | *4* |
| | *Filtering and processing biosignals with the SciPy module* | |
| *7* | *Interaction of a Python application with Arduino microcontrollers* | *4* |
| *8* | *Modular control work* | *4* |
| *9* | *Final Test* | *4* |
| *Total hours* | | *36* |

## 6. Independent student work

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

| № s/n | Types of work submitted for independent work | Duration in hours IW |
|---|---|---|
| 1 | *Review of lecture material and study of questions assigned for independent work* | 10 |
| 2 | *Preparation for practical works* | 36 |
| 4 | *Preparation for modular control work* | 4 |
| 5 | *Performance of computational and graphic work* | 10 |
| 6 | *Preparation for the Final test* | 6 |
| *Total hours* | | 66 |

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

| № s/n | Titles of topics and questions to be studied independently and references to educational literature | Duration in hours IW |
|---|---|---|
| 1 | *Graphical capabilities of Python modules.*<br>*List of questions for independent study: construction of histograms and pie charts [5, 11].* | 5 |
| 2 | *Algorithms for calculating elementary functions.*<br>*List of questions submitted for independent study: creating your own functions (with return) [4, 12].* | 5 |
| 3 | *Numerical methods in Python.*<br>*The list of questions submitted for independent study: optimization (search for minimum/maximum) of functions [11, 12].* | 5 |
| 4 | *Scientific computing in Python.*<br>*List of questions for independent study: manipulations with tabular data (CSV) [5, 12].* | 5 |
| 5 | *Statistical analysis in Python.*<br>*The list of questions submitted for independent study: evaluation of statistical models [10, 12].* | 5 |
| 6 | *Designing Neural Networks in Python.*<br>*List of questions submitted for independent study: machine learning problem from the perspective of probability theory [7, 13].* | 5 |
| 7 | *Image processing in Python.*<br>*List of questions submitted for independent study: blur filter (Gaussian blur) [7, 14].* | 5 |
| 8 | *Signal processing and visualization in Python.*<br>*List of questions submitted for independent study: functions for applying digital filters (FIR, IIR) [8, 9].* | 5 |
| 9 | *Interaction of a Python application program with Arduino microcontrollers.*<br>*The list of questions submitted for independent study: synchronization of the Arduino microcontroller program and the Python program (time.sleep() functions in Python, delay() and Serial.available() in Arduino) [13, 15].* | 6 |
| 10 | *Modular control work* | 4 |
| 11 | *Calculation and graphic work* | 10 |
| 12 | *Final Test* | 6 |
| *Total hours* | | 66 |

*One of the main types of semester control during the mastering of the discipline "Software Engineering in Biomedical Research" is the implementation of calculation and graphic work. Calculation and graphic work is performed in accordance with the requirements, within the period specified by the teacher.*

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

***Approximate subject of calculation and graphic work:***

1. *Function approximation using the SciPy module.*
2. *Function interpolation using the SciPy module.*
3. *Integral calculation using the SciPy module.*
4. *Differential equation calculation using the SciPy module.*
5. *Correlation analysis using the NumPy module.*
6. *Activation function implementation using the NumPy and SciPy modules.*
7. *Backpropagation neural network implementation using the NumPy and SciPy modules.*
8. *Image smoothing and noise removal using the cv2 module.*
9. *Biosignal filtering and processing using the SciPy module.*
10. *Interaction of pySerial and Firmata when visualizing sensor data.*

*The title page of the calculation and graphic 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 discipline; theme of calculation and graphic work; surname and name of the student, course, number of the academic group, year.*

*The title page is followed by a detailed plan (content) of the calculation and graphic work, which should highlight the introduction, sections of the main content (main topics studied), their subdivisions (if necessary), conclusion, list of sources used. The table of contents on the right indicates the page numbers at the beginning of each question. Each section begins on a new page.*

*The total amount of calculation and graphic work, depending on the chosen topic can vary from 20 to 25 pages of the main text (in consultation with the teacher). The amount of computational and graphic work is determined by the student's ability to briefly and at the same time comprehensively explain and analyze the program code in the Code Composer Studio environment.*

*Mandatory requirement: clear reference to sources of information. All figures, facts, opinions of scientists, quotations, formulas should have a reference in the form [2, p. 54] (the first digit means the number of the source in the list of references given at the end of the creative work, and the second digit - the page number in this source). It is desirable to use tables, diagrams, graphs, charts, etc. The list of used sources (not less than 10 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 address of the site on the Internet.*

*Calculation and graphic work is evaluated by the following criteria: logic of the plan; completeness and depth of topic disclosure; reliability of the received data; reflection of practical materials and results of calculations; correctness of formulation of conclusions of the received results and conclusions; design; substantiation of the student's own opinion on this issue in the form of a conclusion.*

*Deadline for submission of calculation and graphic work for verification: 14th week of study.*

*Calculation and graphic work is not tested for plagiarism, but must meet the requirements of academic integrity. In case of academic dishonesty, the work is canceled and not checked.*

## 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.*

*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 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 " Software Engineering in Biomedical Research" 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. | Express control work / test tasks | 14 | 2 | 7 | 14 |
| 2. | Completion and defense of practical work | 24 | 2 | 12 | 24 |
| 3. | Completion and defense of independent work | 27 | 3 | 9 | 27 |
| 4. | Modular control work (MCW) | 15 | 15 | 1 | 15 |
| 5. | Abstract work | 20 | 20 | 1 | 20 |
| 6. | Final Test[1] | 80 | 80 | 1 | 80 |
| | Total | | | | 100 |

[1] *It is taken into account in the total rating together with the RGR score if the student did not score 60 points for the semester or he wants to improve his score.*

*The applicant receives a positive credit score based on the results of work in the semester if he has a final rating for the semester of at least 60 points and has fulfilled the conditions for admission to semester control, which are determined by the Rating Assessment System (RAS).*

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

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

*If the score for the test is lower than the rating, a "hard" RAS is applied - the applicant's previous rating (except for the points for the semester individual assignment) is canceled and he receives a grade taking into account the results of the test. This option forms a responsible attitude of the applicant to making a decision about taking the test, forces him to critically assess the level of his preparation 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 | ≥ 42 points |
| | Execution practical work | PW № 1- 5 | + | + |
| | | PW № 6-12 | - | + |
| | Execution of laboratory works | LW № 1- 4 | + | + |
| | | LW № 5- 9 | - | + |
| | Express control works / test tasks | At least 4 of any lectures | + | - |
| | | At least 8 of any lectures | - | + |
| | Modular control work | Estimated MCW | - | + |
| | Calculation and graphic work | Estimated CGW | - | - |

*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 calculation and graphic work | More than 8 points |
| 3 | All practical works are tested | More than 14 points |
| 3 | All laboratory 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".*

*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* |
| *94-85* | *Very good* |
| *84-75* | *Good* |
| *74-65* | *Satisfactorily* |
| *64-60* | *Enough* |
| *Less 60* | *Unsatisfactorily* |
| *Admission conditions are not met* | *Not allowed* |

## 9. Additional information on the discipline (educational component)

***Appendix 1. Program learning outcomes (extended form)***

*In accordance with the Order of the Ministry of Education and Science of Ukraine No. 1204 dated November 19, 2018 "On approval of the standard of higher education in the specialty 163 Biomedical Engineering" for the first bachelor's level of higher education", in Appendix 1 establishes the correspondence of learning outcomes to competencies in the discipline "Software Engineering in Biomedical Research".*

***Appendix 2. The list of questions for preparation for module control work***

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

*Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students 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 Biomedical Engineering, Doctor of Technical Sciences, Shlykov Vladyslav Valentynovych, Head of the Department of Biomedical Engineering.*

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

***Approved by*** *the Methodical Commission of the Faculty of Biomedical Engineering (protocol № 9 of June 26, 2024)*

*Appendix 1.*

*For syllabus of the discipline "Software Engineering in Biomedical Research"*

***Program learning outcomes (extended form)***

*As a result of studying the academic discipline "Software Engineering in Biomedical Research", students will be able to:*

| Learning outcomes (PRN) | | Compliance of Learning Outcomes with Competencies according to the Higher Education Standard [6] | |
|---|---|---|---|
| | | General Competencies (**soft skills**) | Special Competencies (**professional**) |
| PRN 5 | *Be able to use databases, mathematical and software tools for data processing and computer modeling of biotechnical systems.* | *ЗК 4 - Skills in using information and communication technologies.* | *FK 1 - Ability to apply engineering software packages for research, analysis, processing, and presentation of results, as well as for automated design of medical devices and systems.* |
| PRN 8 | *Understand theoretical and practical approaches to the creation and management of medical equipment and medical technology.* | *ZK 1 - Ability to apply knowledge in practical situations.* | *FK 6 - Ability to effectively use tools and methods for analysis, design, calculation, and testing in the development of biomedical products and services.* |
| PRN 13 | *Be able to analyze signals transmitted from organs to devices and process diagnostic information (signals and images).* | *ZK 5 - Ability to conduct research at an appropriate level.* | *FK 11 - Ability to develop, plan, and conduct experiments using specified technical and biomedical techniques, applying mathematical methods in the analysis and modeling of the functioning of living organisms, systems, and processes in biology and medicine, computer processing, analysis, and synthesis of the obtained results.* |
| PRN 20 | *Knowledge and application of research methods in biomedical engineering, methods and tools for organizing and processing experimental data, statistical methods for modeling and simulating processes and systems of physical and biological nature, modern programming technologies* | *ZK 5 - Ability to conduct research at an appropriate level.* | *FK 3 - Ability to study and apply new methods and tools for analysis, modeling, design, and optimization of medical devices and systems.* |

| Learning outcomes (PRN) | | Compliance of Learning Outcomes with Competencies according to the Higher Education Standard [6] | |
|---|---|---|---|
| | | General Competencies (**soft skills**) | Special Competencies (**professional**) |
| | *and supporting tools, methods for designing digital and microprocessor-based medical systems.* | | |

[6] Order of the Ministry of Education and Science of Ukraine No. 1204 dated November 19, 2018 "On approval of the standard of higher education in the specialty 163 Biomedical Engineering" for the first bachelor's level of higher education".

*Appendix 2.*

*For syllabus of the discipline "Software Engineering in Biomedical Research"*

***The list of questions for preparation for module control work,***

***And also for preparation for test***

*1. Two-dimensional plots with the matplotlib module.*

*2. Three-dimensional plots with the matplotlib module.*

*3. Algebraic calculations with the mpmath module.*

*4. Graphical functions with the mpmath module.*

*5. Approximation of a function using the SciPy module.*

*6. Interpolation of a function using the SciPy module.*

*7. Calculating an integral using the SciPy module.*

*8. Calculating a differential equation using the SciPy module.*

*9. Quantitative data analysis in descriptive statistics using the NumPy module.*

*10. Correlation analysis using the NumPy module.*

*11. Implementing an activation function using the NumPy and SciPy modules.*

*12. Implementing a Backpropagation neural network using the NumPy and SciPy modules.*

*13. Using OpenCV 3 computer vision using the cv2 module.*

*14. Smoothing and removing noise in an image using the cv2 module.*

*15. Compressing and decompressing the WAV audio format using the Wave module.*

*16. Filtering and processing biosignals using the SciPy module.*

*17. Firmata protocol on Arduino UNO v3.*

*18. The pySerial module works on Python 3.6.7.*

*19. Interaction of pySerial and Firmata during visualization of data from sensors.*

*20. Numerical methods of the SciPy module.*