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

Department of Biomedical Engineering, FBME

NEURAL NETWORKS

Course Syllabus

Course Details

Level of Higher Education	*First (Bachelor's) Level*
Field of Study	*16 Chemical and Bioengineering*
Specialty	*163 Biomedical Engineering*
Educational Program	*Medical Engineering*
Course Status	*Elective*
Mode of Study	*Full-time (On-campus)*
Year of Study, Semester	*4th Year, Autumn Semester*
Course Workload	*4 ECTS credits / 120 hours* *Lectures – 28 hours* *Computer Practicals – 26 hours* *Independent Study – 66 hours*
Semester Assessment / Assessment Methods	*Assessment: Pass/Fail, Home Assignment, Modular Test*
Class Schedule	*According to official schedule: https://schedule.kpi.ua/*
Language of Instruction	*Language of Instruction: Ukrainian*
Information about the Course Coordinator / Instructors	*Lecturer: Associate Professor, Department of Biomedical Cybernetics,* *PhD in Physical and Mathematical Sciences,* *Illia V. Fedorin,* *fedorin.illia@lll.kpi.ua* *Practical Classes:* 1. *Associate Professor, Department of Biomedical Cybernetics, PhD in Physical and Mathematical Sciences, Illia V. Fedorin, fedorin.illia@lll.kpi.ua* 2. *Assistant, Department of Biomedical Cybernetics, Oleksii D. Dyumin, bs01mp-dad-fbmi24@lll.kpi.ua* *Laboratory Classes: Not included in the course*
Course Location	*https://do.ipo.kpi.ua/course/view.php?id=6836*

Curriculum of the Academic Discipline

1. Description of the Academic Discipline, Its Purpose, Subject Area, and Learning Outcomes

Purpose – to provide future specialists with a clear understanding of models, methods, and software tools for working with neural networks, in particular for solving problems related to the development of intelligent systems.

Objectives – to provide students with a comprehensive set of knowledge necessary to understand the challenges that arise in the development and use of modern software systems

designed to solve intelligent tasks, as well as to familiarize students with the fundamental principles of neural network design. In the course of studying the discipline, students are expected to acquire the knowledge, abilities, and practical skills required to develop software solutions based on neural networks.

Competencies to be acquired by the learner in accordance with the Educational Program (EP-2024) (approved by the Academic Council of Igor Sikorsky Kyiv Polytechnic Institute on May 13, 2024 (Protocol No. 5) and implemented starting from the 2024/2025 academic year by the Rector's Order of June 06, 2024, No. НОД/434/24):

	General Competencies (GC)
GC 1	*Ability to apply knowledge in practical situations*
GC 6	*Ability to search, process, and analyze information from various sources*
	Professional (Specialized) Competencies (PC)
PC 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.*
PC 3	*Ability to study and apply new methods and tools for analysis, modeling, design, and optimization of medical devices and systems.*
PC 5	*Ability to apply physical, chemical, biological, and mathematical methods in the analysis and modeling of the functioning of living organisms and biotechnical systems.*
PC 8	*Ability to conduct research and observation on the interaction of biological, natural, and artificial systems (prostheses, artificial organs, etc.).*
	Program Learning Outcomes (PLO)
PLO 5	*Be able to use databases, mathematical and software tools for data processing and computer modeling of biotechnical systems.*
PLO 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 technlogies and supporting tools, methods for designing digital and microprocessor-based medical systems.*

2. Prerequisites and Postrequisites of the Course (Position in the structural and logical scheme of training within the relevant educational program)

Within the structural and logical framework of the specialist training program, the academic discipline "Neural Networks" belongs to the list of elective courses aimed at forming professional competencies of specialists in the specialty 163 Biomedical Engineering under the Educational Program " Medical Engineering " at the first (Bachelor's) level of higher education.

The course is supported by Bachelor-level disciplines within the specialty 163 Biomedical Engineering, specialization "Medical Engineering", including:

Basics of Informatics, Object-oriented Programming, Physics, Higher Math: Mathematical Analysis, Probability Theory and Mathematical Statistics.

The discipline is essential for specialists in their further professional practical activities.

3. Course Content

Section 1: Models of Neuron Elements. Widrow–Hoff Learning Method

- **Topic 1.1.** General characteristics and fundamental principles of neural network design. Classification and types of neural network models. Properties of artificial neural networks. General concepts of neural network training. Characteristics of the learning process. Requirements for training datasets. Neural networks in **MATLAB** and **Python-based frameworks (TensorFlow/Keras)**.
- **Topic 1.2.** Single-layer networks. Biological neurons and their physical models. Mathematical models of neuron elements. Concepts: synapse, weight coefficient, threshold, discriminant function, activation function, single-layer perceptron. Least squares method as the basis of the Widrow–Hoff algorithm. Capabilities and properties of single-layer perceptrons. Linear separability and linear inseparability of classes. Models of neuron elements in **MATLAB** and **Python-based frameworks (TensorFlow/Keras)**.

Section 2: Feedforward Neural Networks. Gradient-Based Learning Methods

- **Topic 2.1.** Multilayer networks. Multilayer perceptron: model and principles of architecture design. Backpropagation algorithm. Gradient-based learning algorithms for multilayer neural networks. Comparison of feedforward neural network models and learning algorithms. Feedforward neural networks and gradient learning algorithms in **MATLAB** and **Python-based frameworks (TensorFlow/Keras)**.
- **Topic 2.2.** Radial Basis Function (RBF) networks. Models and principles of RBF neural network architecture synthesis. Training methods for radial basis function networks. Application of cluster analysis in RBF network training. RBF neural networks in **MATLAB** and **Python-based frameworks (TensorFlow/Keras)**.

Section 3: Fully Connected Neural Networks

- **Topic 3.1.** Hopfield networks. Binary fully connected Hopfield neural networks. Pseudo-inverse learning rule, projective weight tuning algorithm. Gorodnichy effect and prospects and methods of its application. Algorithm for desaturation of the synaptic matrix of a Hopfield network.
- **Topic 3.2.** Elman networks. Application of neural networks for associative information retrieval. Hopfield networks in combinatorial optimization problems. Elman neural network. Hopfield and Elman neural networks in **MATLAB** and **Python-based frameworks (TensorFlow/Keras)**.

Section 4: Kohonen Neural Networks

- **Topic 4.1.** Kohonen maps. Kohonen self-organizing feature maps (SOM). Kohonen SOM neural network in **MATLAB** and **Python-based frameworks (TensorFlow/Keras)**.
- **Topic 4.2.** Learning Vector Quantization (LVQ) networks. LVQ neural network. “SOM–LVQ” neural network. Application of Kohonen networks in cluster analysis and geographic information systems. Kohonen LVQ neural network in **MATLAB** and **Python-based frameworks (TensorFlow/Keras)**.

4. Learning Materials and Resources.

For preparation for lectures, computer practical classes, modular assessments, individual self-study assignments, etc., core and supplementary literature (hereinafter referred to as literature) as well as recommended methodological guidelines are used.

The literature required for mastering the discipline is studied by students independently using Internet resources and Google Classroom.

In the context of distance learning, preparation may be carried out using electronic versions of the literature available in Google Classroom for the course.

4.1 Core Literature

1. **Fedorin, I. V.**
   Neironi merezhi. Chastyna 1. Vstup do neironnykh merezh
   [Neural Networks. Part 1. Introduction to Neural Networks]
   [Electronic resource]: study guide for Bachelor's degree students of the educational program *Computer Technologies in Biology and Medicine*, specialty 122 *Computer Science*.
   Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2023. 225 p.
   Available at: https://ela.kpi.ua/handle/123456789/63425
2. **Fedorin, I. V.**
   Neironi merezhi. Chastyna 2. Arkhitektury neironnykh merezh
   [Neural Networks. Part 2. Neural Network Architectures]
   [Electronic resource]: study guide for Bachelor's degree students of the educational program *Computer Technologies in Biology and Medicine*, specialty 122 *Computer Science*.
   Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2023. 177 p.
   Available at: https://ela.kpi.ua/handle/123456789/63426
3. **Fedorin, I. V.**
   Neironi merezhi. Praktykum
   [Neural Networks. Practical Guide]
   [Electronic resource]: study guide for Bachelor's degree students of the educational program *Computer Technologies in Biology and Medicine*, specialty 122 *Computer Science*.
   Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2023. 157 p.
   Available at: https://ela.kpi.ua/handle/123456789/63422
4. **Lytvyn, V. V., Pasichnyk, V. V., Yatsyshyn, Yu. V.**
   Intelektualni systemy
   [Intelligent Systems]
   Textbook. Lviv: Novyi Svit–2000 Publishing House, 2021. 405 p.
   Available at: https://opac.kpi.ua/F/?func=direct&doc_number=000637217&local_base=KPI01
5. **Tymoshchuk, P. V., Lobur, M. V.**
   Pryntsypy shtuchnykh neironnykh merezh ta yikh zastosuvannia
   [Principles of Artificial Neural Networks and Their Applications]
   Study guide. Lviv: Lviv Polytechnic Publishing House, 2020. 291 p.
   Available at: https://opac.kpi.ua/F/?func=direct&doc_number=000638675&local_base=KPI01

4.2 Supplementary Literature

1. **Börgers, C.**
   An Introduction to Modeling Neuronal Dynamics [Electronic resource].
   Cham: Springer International Publishing, 2017. XIII, 457 p.
   (Texts in Applied Mathematics, Vol. 66).
   Available at: https://opac.kpi.ua/F/?func=direct&doc_number=000625209&local_base=KPI01
2. **Xie, M., Chen, H., Hu, Z.**
   New Foundation of Artificial Intelligence.

Hackensack: World Scientific, 2021. 384 p.
Available at: https://opac.kpi.ua/F/?func=direct&doc_number=000637807&local_base=KPI01

3. **Nakonechnyi, M. V., Ivakhiv, O., Nakonechnyi, Yu.**
Neiromerezhevi systemy keruvannia neliniinymy obiektamy
[Neural Network Control Systems for Nonlinear Objects].
Lviv: Rastr-7, 2017. 239 p.
Available at: https://opac.kpi.ua/F/?func=direct&doc_number=000590151&local_base=KPI01
4. **Tkachenko, R. O., Tkachenko, P. R., Izonin, I. V.**
Neiromerezhevi zasoby shtuchnoho intelektu
[Neural Network Tools of Artificial Intelligence].
Study guide. Lviv: Lviv Polytechnic Publishing House, 2017. 206 p.
Available at: https://opac.kpi.ua/F/?func=direct&doc_number=000616936&local_base=KPI01
5. **da Silva, I. N., Spatti, D. H., Flauzino, R. A., Liboni, L. H. B., Alves, S. F. R.**
Artificial Neural Networks: A Practical Course [Electronic resource].
Cham: Springer International Publishing, 2017. XX, 307 p.
Available at: https://opac.kpi.ua/F/?func=direct&doc_number=000233916&local_base=KPI01
6. **Yampolskyi, L. S., Lisovychenko, O. I., Oliinyk, V. V.**
Neirotekhnolohii ta neirokomp'iuterni systemy
[Neurotechnologies and Neurocomputer Systems].
Textbook. Kyiv: Dorado-Druk, 2016. 571 p.
Available at: https://opac.kpi.ua/F/?func=direct&doc_number=000551224&local_base=KPI01
7. **Fedorin, I. V.**
Metody ta tekhnolohii obchysliuvalnoho intelektu
[Methods and Technologies of Computational Intelligence]
[Electronic resource]: study guide for Master's degree students, specialty 122 *Computer Science*.
Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2022. 315 p.
Available at: https://ela.kpi.ua/handle/123456789/50934
8. **Fedorin, I. V.**
Metody ta tekhnolohii obchysliuvalnoho intelektu. Praktykum
[Methods and Technologies of Computational Intelligence. Practical Guide]
[Electronic resource]: study guide for Master's degree students, specialty 122 *Computer Science*.
Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2022. 318 p.
Available at: https://ela.kpi.ua/handle/123456789/50933
9. **Subbotin, S. O.**
Neironi merezhi: teoriia ta praktyka
[Neural Networks: Theory and Practice].
Study guide. Zhytomyr: Yevenok Publishing House, 2020. 184 p.
Available at: http://eir.zntu.edu.ua/bitstream/123456789/6800/1/Subbotin_Neural.pdf
10. **Trotsko, V. V.**
Metody shtuchnoho intelektu
[Methods of Artificial Intelligence].
Educational and practical guide. Kyiv: KROK University of Economics and Law, 2020. 86 p.
Available at: https://library.krok.edu.ua/media/library/category/navchalni-posibniki/trotsko_0001.pdf
11. **Lubko, D. V., Sharov, S. V.**
Metody ta systemy shtuchnoho intelektu
[Methods and Systems of Artificial Intelligence].
Study guide. Melitopol: FOP Odnoroh T. V., 2019. 264 p.
Available at: http://www.tsatu.edu.ua/kn/wp-content/uploads/sites/16/knyha.-msshy-v-byblyoteku.pdf

12. **Dobrovska, L. M., Dobrovska, I. A.**
Shtuchnyi intelekt. Osnovy teorii neironnykh merezh
[Artificial Intelligence. Fundamentals of Neural Network Theory].
Methodological guidelines for practical classes.
Kyiv: NTUU "KPI", 2009. 180 p.
13. **Dobrovska, L. M., Dobrovska, I. A.**
Teoriia ta praktyka neironnykh merezh
[Theory and Practice of Neural Networks].
Study guide. Kyiv: NTUU "KPI", Polytechnic Publishing House, 2015. 396 p.
14. **Gurney, K.**
An Introduction to Neural Networks.
London & New York, 1997. 317 p.
Available at:
https://www.inf.ed.ac.uk/teaching/courses/nlu/assets/reading/Gurney_et_al.pdf
15. **Hagan, M. T., Demuth, H. B., Beale, M.**
Neural Network Design.
USA: Colorado University Bookstore, 2002. 734 p.
16. **Haupt, R. L., Haupt, S. E.**
Practical Genetic Algorithms.
2nd ed. A Wiley-Interscience Publication. 253 p.
17. **Luke, S.**
Essentials of Metaheuristics: A Set of Undergraduate Lecture Notes.
September 2009.
Available at: http://cs.gmu.edu/~sean/book/metaheuristics/
18. **Stanley, K. O.**
Efficient Evolution of Neural Networks Through Complexification.
PhD Thesis, Department of Computer Sciences,
The University of Texas at Austin, 2004.
19. **Yao, X.**
Evolving artificial neural networks.
Proceedings of the IEEE, 1999, Vol. 87, No. 9, pp. 1423–1447.
20. **Zhang, X.**
A mathematical model of a neuron with synapses based on physiology.
Nature Precedings, 2008.
https://doi.org/10.1038/npre.2008.1703.1

4.3 Additional Resources (Information Resources): resources from open-access platforms, subscription-based licensed databases (e.g., Springer, Elsevier), and open educational resources (OERs):

1. **Gu, J., Wang, Z., Kuen, J., et al.**
Recent advances in convolutional neural networks.
Pattern Recognition, 77 (2018), 354–377.
Available at: https://arxiv.org/pdf/1512.07108.pdf
2. **Gurney, K.**
An Introduction to Neural Networks.
CRC Press, 2018.
Available at: http://www.macs.hw.ac.uk/~yjc32/project/ref-NN/Gurney_et_al.pdf
3. **Hajian, A., Styles, P.**
Artificial neural networks.
In: *Application of Soft Computing and Intelligent Methods in Geophysics*.
Springer, Cham, 2018, pp. 3–69.

Available at:
https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.301.5738&rep=rep1&type=pdf

4. **Khokhlov, A. V., Mikheienko, D. Yu.**
Vykorystannia neiromerezh dlia rozviazannia zadach prohnozuvannia
[Application of Neural Networks for Solving Forecasting Problems].
Conference proceedings, 2020, p. 140.
Available at:
http://www.dgma.donetsk.ua/docs/kafedry/tiup/konf/%D0%9D%D0%9C%D0%A2%D1%96%D0%97_2020.pdf#page=140

Learning Content

5. Methodology of Mastering the Academic Discipline (Educational Component)

During the study of the credit module, 14 lecture sessions and 13 computer practical sessions (10 computer practicals) are scheduled, as well as the completion of a modular assessment and a home assignment.

The following teaching methods are applied in the process of studying the course material.

During lectures, the instructor presents the essence of scientific concepts, phenomena, and processes in a verbal form, logically interconnected and unified by a common topic.

The effectiveness of lectures is impossible without the extensive use of visual teaching methods, which are determined by the dialectical principles of cognition and the psychological characteristics of perception. The visual method involves the use of an explanatory–illustrative approach during lectures of the credit module.

At the same time, students should understand that the primary source of scientific information is not the instructor but academic literature. Therefore, it is important that students independently work with textbooks and additional sources by reading and taking notes that supplement the lecture material.

Keeping lecture notes enables students to:

- better prepare for the pass/fail assessment of the credit module;
- resolve disputable issues related to incomplete or inaccurate answers during the assessment.

During computer practical sessions, instructional guidance plays a significant role. It includes explaining rules of conduct, specifics of using methods and learning tools, and compliance with safety regulations while performing educational tasks. It is important that students understand not only what needs to be done, but also how it should be done.

The effectiveness of computer practical sessions largely depends on the way students' thinking is organized. In this context, a partially exploratory method, as well as practical and reproductive methods, are applied.

The partially exploratory method encourages active search for solutions to assigned tasks, which students perform independently under the guidance of the instructor or based on methodological guidelines and presentations. In this process, students' thinking becomes productive while being gradually directed and monitored by the instructor or by the students themselves through structured work on computer practical assignments.

Using the practical method, students acquire knowledge and skills necessary to perform practical actions during computer practicals and to complete individual assignments. The reproductive method, based on methodological recommendations and example solutions, enables students to form stable knowledge, skills, and abilities required to accomplish the assigned tasks.

Below is the distribution of classroom hours by course topics:

Sections and Topics	*Number of Hours*			
	Total	*Lectures*	*Practical classes*	*Independent Study*
Section 1. Models of Neuron Elements. Widrow–Hoff Learning Method				
Topic 1.1. General characteristics and fundamental principles of neural network design	*3*	*2*		*1*
Topic 1.2. Single-layer networks. Biological neurons and their physical models. Mathematical models of neuron elements	*7*	*2*	*2*	*3*
Section 2. Feedforward Neural Networks. Gradient-Based Learning Methods				
Topic 2.1. Multilayer networks	*11*	*4*	*4*	*3*
Topic 2.2. Radial Basis Function (RBF) networks	*12*	*4*	*4*	*4*
Section 3. Fully Connected Neural Networks				
Topic 3.1. Hopfield networks	*11*	*4*	*4*	*3*
Topic 3.2. Elman networks	*12*	*4*	*4*	*4*
Section 4. Kohonen Neural Networks				
Topic 4.1. Kohonen maps	*11*	*4*	*4*	*3*
Topic 4.2. Learning Vector Quantization (LVQ) network	*12*	*4*	*4*	*4*
Home Assignment	*10*			*10*
Modular Assessment	*4*		*(2)*	*4*
Pass/Fail Assessment	*6*		*(2)*	*6*
Total	***120***	***28***	***26***	***66***

The alignment of teaching and assessment methods is reflected in the rating-based assessment system, which includes: defense of reports for computer practicals (CP), a modular assessment, an individual assignment, and a final test.

5.1 Lectures

№	***Lecture Topic Title and List of Key Issues*** *(list of teaching aids, independent study tasks with references to the literature)*
1	**General Characteristics and Fundamental Principles of Neural Network Design** History of neural networks, principles of neural network construction, concepts of neuron and perceptron, mathematical definition of a neuron.
	Independent Study Tasks 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–5]; Supplementary: [6–12, 17–20]

№	***Lecture Topic Title and List of Key Issues*** *(list of teaching aids, independent study tasks with references to the literature)*
	Program Learning Outcomes: PLO-5 **Professional (Specialized) Competencies (PC):** PC-1, 3
2	**Classification and Types of Neural Network Models** Classification and varieties of neural networks. Advantages and disadvantages. Specific features of application. Practical problems solved by neural networks. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–5]; Supplementary: [6–12, 17–20] **Program Learning Outcomes:** PLO-5 **Professional (Specialized) Competencies (PC):** PC-1, 3
3	**Properties of Artificial Neural Networks. General Concepts of Neural Network Training** Properties of neural networks. Principles of neural network training. Loss function. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–5]; Supplementary: [6–12, 17–20] **Program Learning Outcomes:** PLO-5 **Professional (Specialized) Competencies (PC):** PC-1, 3
4	**Multilayer Networks. Multilayer Perceptron: Model and Architecture Design Principles** Principles of neural network construction. Multilayer networks. Training principles of multilayer networks. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–5]; Supplementary: [20–25] **Program Learning Outcomes:** PLO-5, PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8
5	**Backpropagation Algorithm. Comparison of Feedforward Network Models and Learning Algorithms** Neural network training process. Backpropagation algorithm. Optimization algorithms for neural networks. Advantages and disadvantages. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–5]; Supplementary: [20–25] **Program Learning Outcomes:** PLO-5, PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8
6	**Feedforward Neural Networks and Gradient-Based Learning Algorithms in MATLAB / Python Frameworks (TensorFlow/Keras)** Principles of construction and software implementation of feedforward networks. Implementation of optimization algorithms. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical.

№	***Lecture Topic Title and List of Key Issues*** *(list of teaching aids, independent study tasks with references to the literature)*
	Literature Core: [1–5]; Supplementary: [20–25] **Program Learning Outcomes:** PLO-5, PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8
7	**Hopfield Networks** Fundamentals of Hopfield neural network architecture. Features of training and architecture. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–3, 5]; Supplementary: [14–17] **Program Learning Outcomes:** PLO-5, PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8
8	**Binary Fully Connected Hopfield Neural Networks** Advantages and disadvantages of Hopfield networks. Variants of Hopfield networks. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–3, 5]; Supplementary: [14–17] **Program Learning Outcomes:** PLO-5, PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8
9	**Pseudo-Inverse Learning Rule. Projective Weight Tuning Algorithm** Learning rules based on Hopfield networks. Optimization of Hopfield networks. Features of training and testing. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–3, 5]; Supplementary: [14–17] **Program Learning Outcomes:** PLO-5, PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8
10	**Gorodnichy Effect: Prospects and Methods of Application** Essence of the Gorodnichy effect. Practical recommendations for its application. Practical aspects of using Hopfield networks. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–3, 5]; Supplementary: [14–17] **Program Learning Outcomes:** PLO-5, PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8
11	**Kohonen Maps** Essence of Kohonen networks. Advantages and disadvantages. Basic principles of network construction. Practical applications. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature**

№	***Lecture Topic Title and List of Key Issues*** *(list of teaching aids, independent study tasks with references to the literature)*
	Core: [1–3]; Supplementary: [10–15] **Program Learning Outcomes:** PLO-20 **Professional (Specialized) Competencies (PC):** PC-5, 8
12	**Kohonen Self-Organizing Feature Maps (SOM)** Concept of feature maps. SOM neural network: construction features, advantages and disadvantages, applications. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–3]; Supplementary: [10–15] **Program Learning Outcomes:** PLO-20 **Professional (Specialized) Competencies (PC):** PC-5, 8
13	**Kohonen SOM Neural Network in MATLAB** Features of software implementation of Kohonen and SOM networks in MATLAB. **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–3]; Supplementary: [10–15] **Program Learning Outcomes:** PLO-20 **Professional (Specialized) Competencies (PC):** PC-5, 8
14	**Kohonen SOM Neural Network in Python-Based Frameworks (TensorFlow/Keras)** Features of software implementation of Kohonen and SOM networks in modern Python-based deep learning frameworks (TensorFlow/Keras). **Independent Study Tasks** 1. Study lecture materials. Review the recommended literature. Learn key terms and basic concepts of the topic. Prepare for the computer practical. **Literature** Core: [1–3]; Supplementary: [10–15] **Program Learning Outcomes:** PLO-20 **Professional (Specialized) Competencies (PC):** PC-5, 8

5.2 Computer Practicals (CP)

Main Objectives of the Computer Practicals Cycle:

- development of skills for the optimal and efficient application of modern information technologies in the design of software components and the development of machine learning algorithms and deep neural networks;
- acquisition of the ability to apply theoretical knowledge in practical activities;
- mastery of techniques for algorithm development using the **Python** programming language and **deep learning frameworks (TensorFlow/Keras)**;
- independent development and creation of software that implements various approaches to using high-level data types.

	Title of the Topic / Block *(list and titles of computer practicals and literature)*	*Number of Hours*
1.	**CP №1: Introduction to Working with Python Modules *NumPy, Pandas, Matplotlib*** **Literature** Core: [1–3]; Supplementary: [5–8] **Program Learning Outcomes:** PLO-5	*2*

	Professional (Specialized) Competencies (PC): PC-1, 3	
2.	**CP №2: Optimization Methods for Neural Networks** **Literature** Core: [1–3]; Supplementary: [5–8] **Program Learning Outcomes:** PLO-5 **Professional (Specialized) Competencies (PC):** PC-1, 3	*2*
3	**CP №3: Development of a Simple Neural Network for a Classification Task Using Gradient Descent** **Literature** Core: [1–3]; Supplementary: [5–8] **Program Learning Outcomes:** PLO-5 **Professional (Specialized) Competencies (PC):** PC-1, 3	*2*
4	**CP №4: Introduction to TensorFlow/Keras for Neural Network Development and Training. Implementation of a Multilayer Neural Network Using a Regression Task as an Example** **Literature** Core: [1–3]; Supplementary: [5–8] **Program Learning Outcomes:** PLO-5 **Professional (Specialized) Competencies (PC):** PC-1, 3	*2*
5	**CP №5: Initialization, Normalization, and Regularization in Neural Networks** **Literature** Core: [1–3]; Supplementary: [11, 15] **Program Learning Outcomes:** PLO-5, PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8	*4*
6	**CP №6: Development of a Recurrent Neural Network** **Literature** Core: [1–3]; Supplementary: [11, 15] **Program Learning Outcomes:** PLO-5, PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8	*4*
7	**CP №7: Convolution. Development of a Convolutional Neural Network** **Literature** Core: [1–3]; Supplementary: [11, 15] **Program Learning Outcomes:** PLO-5, PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8	*4*
8	**CP №8: Development of a Siamese Network** **Literature** Core: [1–3]; Supplementary: [21–25] **Program Learning Outcomes:** PLO-20 **Professional (Specialized) Competencies (PC):** PC-5, 8	*2*
9	**CP №9: Development of an Autoencoder (3 hours)** **Literature** Core: [1–3]; Supplementary: [21–25] **Program Learning Outcomes:** PLO-20 **Professional (Specialized) Competencies (PC):** PC-5, 8	*2*
10	**CP №10: Application of the Transfer Learning Concept** **Literature** Core: [1–3]; Supplementary: [21–25] **Program Learning Outcomes:** PLO-20 **Professional (Specialized) Competencies (PC):** PC-1, 3, 5, 8	*2*
	Modular Assessment	*(2)**

	Pass/Fail Assessment	*(2)**
Total		*26*

- Additional (Unscheduled) Classes

Distance Learning Platform:

To ensure better assimilation of the course material during the period of distance learning, email communication, the "Sikorsky" distance learning platform based on Google Classroom, and online meeting platforms Google Meet and Zoom are used. These tools enable:

- simplified distribution of methodological guidelines, learning materials, and literature;
- feedback and communication with students regarding learning tasks and course content;
- submission, review, and assessment of completed assignments;
- monitoring students' progress in completing the course requirements, compliance with submission schedules for learning and individual assignments, and their evaluation.

6. Independent Study

Independent study includes: preparation for lectures and computer practicals; participation in discussions on the relevant topics; self-assessment of acquired knowledge; study of recommended sources and literature; preparation for the modular assessment and individual assignment; and preparation for the pass/fail assessment, etc.

6.1 Topics for Independent Study:

No.	Titles of topics and issues assigned for independent study and references to learning materials	Number of self-study hours
1	Topic 1.1. General characteristics and basic principles of neural network construction. Issues for independent study: history of neural network development, learning paradigms, classes of problems. References: [1, pp. 12–35; 4, pp. 45–62; 5, pp. 18–30].	1
2	Topic 1.2. Single-layer networks. Issues for independent study: perceptron, physical models of neurons, limitations. References: [1, pp. 36–78; 9, pp. 22–41; 14, pp. 55–80].	3
3	Topic 2.1. Multilayer neural networks. Issues for independent study: network depth, gradient-related problems, regularization. References: [2, pp. 25–60; 15, pp. 101–145; 4, pp. 120–148].	3
4	Topic 2.2. Radial basis function neural networks. Issues for independent study: RBF functions, selection of centers, computational complexity. References: [2, pp. 61–95; 9, pp. 75–102; 15, pp. 210–235].	4
5	Topic 3.1. Hopfield networks. Issues for independent study: associative memory, energy-based approach. References: [2, pp. 96–120; 6, pp. 210–235; 14, pp. 181–205].	3
6	Topic 3.2. Elman networks. Issues for independent study: recurrence, context neurons. References: [2, pp. 121–155; 7, pp. 88–115; 11, pp. 140–168].	4
7	Topic 4.1. Kohonen maps. Issues for independent study: self-organization, clustering. References: [2, pp. 156–185; 6, pp. 260–295; 9, pp. 110–132].	3
8	Topic 4.2. Learning Vector Quantization (LVQ) network. Issues for independent study: LVQ algorithms, classification. References: [2, pp. 186–210; 6, pp. 296–320; 15, pp. 305–330].	4

9	Home assignment. Independent study of theoretical material, completion of individual tasks, and preparation of a written report. References: [1–3, 9, 15].	10
10	Module assessment. Revision and systematization of the material of the corresponding module. References: [1, 2, 4, 9].	4
11	Final assessment (pass/fail). Generalization of theoretical foundations of the course and preparation for final assessment. References: [1–5, 9, 15].	6
	Total:	**66**

6.2 Preparation for Lectures and Computer Practicals

To prepare for lectures and computer practicals, students are required to study the scheduled **core and supplementary literature**, recommended sources, and to prepare materials for discussion and practical implementation during classes. For this purpose, students are allocated **1–1.5 hours for each course topic**.

6.3 Modular Assessment

Preparation for the modular assessment requires **4–6 hours of independent study**. The list of questions for preparation for the modular assessment is provided in **Appendix B**.

6.4 Home Assignment

Preparation and submission of the home assignment requires **10–15 hours of independent study**.

The topic of the home assignment must be selected by the student and approved by the instructor **no later than four weeks after the beginning of classes**. A recommended list of home assignment topics is provided in **Appendix D**. Methodological guidelines for preparing the home assignment are provided in **Appendix D1**. The deadline for submitting the home assignment to the instructor is **no later than the 13th week**. The defense of the home assignment is scheduled as an **additional (unscheduled) class during weeks 14–15**.

6.5 Pass/Fail Assessment

The credit (pass/fail assessment) is conducted according to the schedule **in week 16**. Based on the total number of rating points accumulated during the semester, a student receives a pass without additional assessments if the total score **is at least 60 points**. Students who have met all admission requirements for the credit and have up to 59 rating points, or who wish to improve their result, must complete a credit control test or undergo an oral interview based on the credit questions and tasks. **Up to 6 hours of independent study** time are allocated for preparation for the credit. The list of questions and tasks for credit preparation is provided in **Appendix A.** During periods of distance learning, the credit may be conducted according to the class schedule using Google Classroom and the Google Meet online meeting platform.

Policy and Assessment Control

7. Course Policy (Educational Component)

Students are expected to comply with the rules of class attendance and appropriate conduct during classes.

7.1. Attendance Policy

Lectures.

At present, there are virtually no up-to-date Ukrainian-language (or foreign-language) textbooks fully dedicated to this subject area. Therefore, it is critically important for students to attend lectures, during which systematically structured course material and presentations of documents are provided in a volume sufficient for mastering the discipline.

Lecture attendance for this course is **mandatory**, as lectures provide the essential theoretical foundation that enables students to adequately prepare for computer practicals, the modular assessment, the home assignment, and the pass/fail assessment. There is very little new educational

material available outside the lectures, and the existing materials are often outdated and do not reflect current developments. Consequently, active participation in lectures is necessary for students who aim to demonstrate excellent learning outcomes. However, **missed lectures do not require make-up sessions**.

Computer Practicals.

Active participation in computer practicals (hereinafter referred to as *classes*) is **mandatory**. A significant portion of the student's overall rating is formed based on performance during these classes. Each missed class (regardless of the reason) results in a reduction of the student's final rating for the course.

There is no fixed number of missed classes that automatically requires additional individual consultations with the instructor. However, students who miss classes may receive a low rating that **prevents admission to the pass/fail assessment**. In such cases, the topics of missed classes must be studied independently, and the corresponding reports must be completed and successfully defended.

7.2. Assignment Completion Rules

While studying the course material of the discipline **"Neural Networks"**, students:

Independently:

- prepare for the modular assessment;
- prepare for classes and complete reports;
- complete the home assignment;
- prepare reports and the home assignment in accordance with formatting requirements.

During classes:

- participate in discussions and interactive learning activities;
- complete the modular assessment and the individual assignment (home assignment) on time;
- complete and defend reports for computer practicals (hereinafter referred to as *reports*).

Topics and tasks for classes, the modular assessment, and the home assignment are specified in the course syllabus and are available in the student's personal account in the **Campus system**, in **Google Classroom** on the **Sikorsky platform**, and other official course resources. Tasks and materials for the modular assessment and the home assignment are provided in the appendices to the course syllabus.

7.3. Code of Conduct During Classes

Lecture topics are specified in the syllabus. The structure of lecture material is designed to form a coherent system of presentation, including clear definitions of scientific concepts, phenomena, and processes that are logically interconnected and united by a common topic.

During lectures, the instructor emphasizes the development of students' logical thinking, understanding of logical reasoning, and the ability to use the **Python programming language** for building machine learning algorithms and artificial neural networks. Dialogue between students and the instructor is encouraged during lectures.

The topics of computer practicals are also specified in the syllabus. During practical classes, discussions on problematic course issues are encouraged, with the aim of helping students form their own viewpoints and critically evaluate the presented material.

During classes, the instructor summarizes and analyzes errors and shortcomings in students' presentations or work, answers students' questions, while students evaluate each other's presentations by supplementing or identifying weaknesses.

Active participation of every student in discussions is expected. Students should be able to explain why they have formed a particular opinion and to express their views regarding the opinions of other students.

Students who miss classes are expected to prevent a decrease in their final rating by timely (within the semester) independent study of the relevant topics and completion of the required tasks for missed classes.

The use of laptops and smartphones during lectures and classes is permitted **only for purposes related to the topic of the class and corresponding assignments**. Their use for entertainment or unrelated communication during classes is not allowed. Answering the instructor's questions by reading directly from a smartphone, laptop, or textbook is also discouraged, as it negatively reflects the student's level of preparation.

Students may use their own prepared written notes during classes; however, expressing opinions by reading directly from a sheet of paper is not recommended, as this also indicates insufficient preparation.

The use of materials from unreliable Internet sources (not recommended by the instructor) is discouraged, as such materials are often of low quality, outdated, or contain unreliable information.

7.4. Rules for Completing the Individual Assignment (Home Assignment)

The topic of the home assignment must be selected by the student and approved by the instructor **no later than the 4th week from the beginning of classes**. Students may choose a topic from the list proposed by the instructor or suggest their own topic.

The home assignment must be completed:

- in accordance with the methodological guidelines (**Appendix D1**);
- in compliance with **academic integrity principles**, including independent completion of the work; proper citation of information sources; compliance with copyright and related rights legislation; and provision of accurate information about sources.

In case of violation of academic integrity, the home assignment is **not credited**, and the student **may be expelled from the university**.

The home assignment must be submitted to the instructor **no later than the 13th week**. The home assignment is **not subject to plagiarism detection**, as it contains a significant amount of general and theoretical information.

The defense of the home assignment is scheduled as an **additional (unscheduled) class during weeks 14–15**, using multimedia equipment.

7.5. Incentive and Penalty Points

Incentive Points (max 10 points)

1. Participation in the faculty-level academic competition in the discipline – **6 points**;
2. Modernization/improvement of practical works – **6 points**;
3. Completion of tasks aimed at improving didactic materials for the discipline – **6 points**.

Penalty Points – not planned

7.6. Deadline and Resit Policy

Missed lecture material is compensated through intensified preparation for computer-based practical classes.

According to clauses 3.1–3.2 of the Regulations (https://osvita.kpi.ua/node/37), failure by a student to complete current assessment activities (such as defense of computer practical reports (Section 5.2 of the Syllabus), completion of parts of the modular assessment (Section 5.2 of the

Syllabus), tests, etc.) during scheduled synchronous classes **without a valid reason** results in a score of **0 points**.

If assessment activities are missed for valid reasons, the student is granted the opportunity to complete them at a time and in a form determined by the instructor. The assessment of such completed activities is carried out in accordance with the **Rating System for Learning Outcomes Assessment** (Section 8 of the Syllabus).

The **home assignment (home control task)** must be submitted **no later than Week 13** and defended in **Week 15**, but **no later than 17:00 on Saturday of Week 15**. Failure to meet these requirements results in **0 points for the home assignment** and **non-admission to the exam/credit**.

All scheduled **computer practical reports** must be submitted to the instructor **no later than Wednesday of Week 15 at 23:59** and defended **no later than 17:00 on Saturday of Week 15**.

Students are advised **not to wait until the examination session** to contact the instructor regarding missed assessment activities. It is recommended to complete missed assessments as soon as possible.

Detailed criteria for assessing learning outcomes are defined in the **Regulation on the Rating System of Assessment (RSO)** for the discipline, which is an appendix to the working curriculum and in **Appendix C of the syllabus**.

7.7. University Policy

Academic Integrity

The policy and key 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". More details: https://kpi.ua/code.

Additional information on academic integrity is provided in the **Regulation on the System for Preventing Academic Plagiarism at Igor Sikorsky KPI**: https://osvita.kpi.ua/node/47 and on the university website: https://kpi.ua/academic-integrity

Ethical Conduct

Standards of ethical conduct for students and staff are defined in **Section 2 of the Code of Honor** of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More details: https://kpi.ua/code.

Artificial Intelligence Usage Policy

The policy on the use of artificial intelligence and its principles are regulated by the order **"Policy on the Use of Artificial Intelligence for Academic Activities at Igor Sikorsky KPI"**. More details: https://osvita.kpi.ua/node/1225

8. Types of Assessment and the Rating-Based Assessment System (RAS)

8.1. Types of Assessment

1. Continuous Assessment – Continuous assessment is carried out during scheduled classes and aims to evaluate the level of students' preparedness for coursework. Computer-based practical classes are conducted in the form of completing practical tasks and defending Computer Practical Reports. The modular assessment is conducted once per semester in written form (tests during distance learning) during computer practical classes. Preparation, formatting, and defense of the individual assignment (Home Assignment, HA) are also taken into account.

2. Calendar Assessment

Calendar assessment (CA) is conducted according to the academic schedule. The first assessment takes place in Week 7 (the requirement is a current rating of at least 15 points), and the second assessment takes place in Week 13 (the requirement is a current rating of at least 30 points).

Criterion			**First Assessment**	**Second Assessment**
Assessment period			Week 7	Week 13
Conditions for passing	Current rating		≥ 15-17 points	≥ 30-32 points
	Current control measure	Modular assessment 1.1.	–	+
	Computer Practical Reports	№№ 1-4.	+	+
		№№ 5-8.	–	+
		№№ 9-10.	–	–

3. Semester Assessment: Credit (Pass)

The semester assessment is conducted in the form of a **credit test**. According to clauses 3.8–3.10, 3.12 of the Regulations (https://osvita.kpi.ua/node/37):

1. The **rating grade** for the discipline is communicated to the student during the examination session in **Week 16**.
2. Students who have fulfilled all admission requirements and accumulated **60 or more points** receive the credit **without completing the credit test**.
3. Students who have fulfilled all admission requirements but accumulated **less than 60 points**, as well as those wishing to improve their rating, must complete the **credit test**, which is graded on a **100-point scale**.
4. If a student attempting to improve their rating obtains a lower score than their current rating, the **current rating is retained**.

Credit Test Structure

The credit test consists of **two variants**.

Variant 1

For students who:

- fulfilled all admission requirements,
- completed all parts of the modular assessment,
- defended all computer practical reports,
- but scored less than 60 points or wish to improve their rating.

Maximum score: 100 points

Component	**Points**
Section I. Introduction to Neural Networks	35
Section II. Neural Network Architectures	35

Home Assignment (session score)	30

Assessment criteria for one exam question:

- **30–35 points** – complete answer (≥90% of required information), correct pseudocode and solution algorithm
- **20–25 points** – sufficiently complete answer (≥60%)
- **10–15 points** – incomplete answer (≥60%)
- **0 points** – incorrect or missing answer (<60%)

Variant 2

For students who:

- fulfilled admission requirements,
- but did not complete all parts of the modular assessment and/or did not defend all practical reports **without valid reasons**, resulting in 0 points (clauses 3.1–3.3 of the Regulations).

Maximum score: 100 points

Component	**Points**
Section I. Fundamentals of Neural Networks	25
Section II. Neural Network Architectures	25
Test task or interview for missed modular parts	20
Home Assignment (session score)	30

Assessment criteria for test/interview:

- **12–20 points** – correct answers (≥60%)
- **0 points** – missing answers or <60% correct

Assessment criteria for one exam question:

- **20–25 points** – complete answer (≥90%)
- **10–15 points** – sufficiently complete answer (≥75%)
- **5–8 points** – incomplete answer (≥60%)
- **0 points** – incorrect or missing answer (<60%)

Appeal Procedure

Detailed assessment criteria are defined in the **Regulation on the Rating System for the Discipline** (Appendix C to the syllabus). A student may appeal the instructor's grade by submitting a written complaint **no later than the next day** after receiving the grade. Appeals are reviewed according to university-established procedures.

Admission Requirements for Semester Assessment

Timely submission and defense of **all Computer Practical Reports** and the **Home Assignment**.

Table: Conversion of Rating Scores to University Grades

Points	Grade
100–95	Excellent
94–85	Very Good
84–75	Good
74–65	Satisfactory
64–60	Sufficient
< 60	Unsatisfactory
Admission requirements not met	Not Admitted

Marks in the Semester Record

- **Not Admitted** – failure to meet admission requirements (late submission or defense of reports or HA)
- **Removed** – violation of academic integrity or ethical norms
- **Absent** – student was admitted but did not attend the credit test

8.2 Assessment Structure and Weighting

The final rating consists of points obtained for:

1. Defense of **10 computer practical reports**
2. Modular assessment
3. Home Assignment
4. Credit test

Assessment Weighting

No.	Assessment Type	%	Weight	Quantity	Total
1	Practical reports defense	60	6	10	60
2	Home Assignment	30	30	1	30
3	Modular assessment	10	10	1	10
	Total	100			100

Contribution to Final Rating

- Practical classes (reports) – **60%**
- Modular assessment – **10%**

- Home Assignment – **30%**

Conditions for Achieving the Highest Rating

A student achieves the highest rating if they:

- submit and defend all reports on time and in accordance with formatting requirements;
- actively participate in classes, provide complete and well-reasoned answers, clearly articulate their own position, and engage in discussion;
- complete and properly format the Home Assignment on time;
- prepare for and complete the modular assessment (only **one attempt** is allowed).

Missed classes, inaccuracies, incomplete answers, errors, or reliance on unreliable information sources result in a reduced rating.

Students are expected to actively participate in discussions and justify their viewpoints, as well as critically evaluate the opinions of others.

9. Additional Information on the Course (Educational Component).

The list of questions for the semester assessment (pass/fail assessment) is provided in Appendix A to the syllabus.

If a student has documents confirming participation in academic competitions (city-level, intercity, national, etc.) related to the topic of a class or a section of the credit module, such participation may be credited under the corresponding topic and awarded the appropriate points within the Rating-Based Assessment System (RAS).

Recommendations for Students.

During lectures, students are advised to take notes on key concepts, features, principles, classifications, definitions, and algorithms presented by the instructor. This will facilitate a better understanding of the material, improve preparation for computer practicals, and enable students to provide well-reasoned answers to possible questions.

When preparing for practical classes, it is important to actively participate in discussions. If, for any reason, a student has not reviewed the learning material in advance, they should carefully listen to other participants and attempt to compensate for gaps in preparation using the information obtained. Students are encouraged not to refuse answering the instructor's questions. Even if the correct answer is unknown, it is advisable to attempt an answer and express one's own opinion based on existing knowledge, experience, and logical reasoning. Students should not be afraid of making mistakes, as one of the key objectives of the course is to develop logical thinking and the ability to clearly articulate one's own ideas.

At the same time, lack of knowledge of the course material is considered a significant shortcoming and negatively affects the overall final rating. Responsible preparation for each class contributes to better mastery of the material and reduces the workload during the semester assessment.

An important aspect of proper preparation is developing the ability to work with documents that have practical significance for solving assigned tasks. When becoming acquainted with a new information source or document, students should first assess its reliability and understand the logic and sequence of the presented material. Such analysis helps not only to better assimilate information but also to understand the sequence of actions in software product development.

In case of difficulties in understanding certain stages of software development, students should not hesitate to contact the instructor, who will provide the necessary assistance.

Extracurricular Activities.

Students may participate in: annual industry exhibitions such as "Healthcare", as well as specialized seminars, scientific conferences, and related events.

Distance Learning.

Under distance learning conditions, the educational process is organized using distance learning technologies, including the “Sikorsky” distance learning platform and the Electronic Campus system.

The distance learning process is conducted in accordance with the approved class schedule. Classes are held using modern tools for online meetings, including video conferencing technologies.

Inclusive Education.

Inclusive education is permitted.

Course Syllabus Information: prepared by

Associate Professor at the Department of Biomedical Cybernetics, PhD in Physical and Mathematical Sciences, Associate Professor, Illia V. Fedorin
(position, academic degree, academic title, full name)

Approved by the department of **Biomedical Engineering** (Protocol № __ dated _____ __, 20__)

Approved by the Methodological Commission of the FBME Faculty[1] (Protocol № __ dated ____ __, 20__)

[1] by the University Methodological Council – for university-wide courses.

Appendix A

List of Questions for the Semester Assessment (Pass/Fail Assessment)

Block I. Fundamentals of Neural Networks

1. Concepts: neuron, neural network, neurocomputer, neuroinformatics.
2. Classification and types of neural network models.
3. Properties of artificial neural networks.
4. General understanding of neural network training.
5. General characteristics and principles of neural network construction.
6. Characteristics of the neural network training process.
7. Linear separability and non-linear separability of classes.
8. Comparison of models and learning algorithms for feedforward neural networks.
9. What is a perceptron?
10. Describe a basic perceptron.
11. Main concepts of perceptron theory: signal-based and predicate-based descriptions.
12. Learning algorithms (supervised and unsupervised learning).
13. Backpropagation method.
14. What traditional errors exist?
15. Capabilities and limitations of the model.
16. Multiclass perceptron.
17. Backpropagation neural network.
18. Structure and general rules of backpropagation.
19. Backpropagation algorithm: advantages, disadvantages, and modifications.

Block II. Neural Network Architectures

20. Kohonen network: structure and general principles.
21. Algorithm for constructing a Kohonen network: advantages, disadvantages, and modifications.
22. Hopfield network: structure and general principles.
23. Algorithm for constructing a Hopfield network: advantages, disadvantages, and modifications.
24. Hamming network: structure and general principles.
25. Algorithm for constructing a Hamming network: advantages, disadvantages, and modifications.
26. Define the following concepts: fully connected Hopfield network, computational energy function, associative memory, pseudoinverse learning rule, projection weight-tuning algorithm, desaturation effect (Gorodnichy effect), prototype (reference pattern).
27. Binary fully connected Hopfield neural networks.
28. Pseudoinverse learning rule and projection weight-tuning algorithm.
29. Do the Hopfield model and traditional learning methods allow constructing an associative memory device capable of storing as many patterns as there are neurons in the network? Explain your answer.
30. What problems can be solved using binary Hopfield neural networks? Provide examples.
31. Is it reasonable to use binary Hopfield networks for classification of complex (nonlinearly separable) patterns?
32. Do projection learning algorithms for Hopfield networks always converge?
33. Gorodnichy effect and prospects for its application.
34. Desaturation method of the synaptic matrix in Hopfield networks.
35. Elman networks.
36. Application of neural networks for associative information retrieval.

37. Hopfield networks in combinatorial optimization problems.
38. Kohonen maps.
39. Kohonen self-organizing feature maps (SOM).
40. Kohonen SOM neural network in the MATLAB package.
41. Application of Kohonen networks in cluster analysis and geographic information systems.

Block III. Test Task or Oral Examination

1. **Autoencoder.** Implement a simple autoencoder network in Keras or PyTorch for MNIST image compression. Visualize reconstructed images and explain how the latent space is formed.
2. **Autoencoder vs. PCA.** Conduct an experiment comparing autoencoder performance with Principal Component Analysis (PCA) for dimensionality reduction.
3. **Convolutional Neural Network (CNN).** Implement a CNN for image recognition using CIFAR-10 or MNIST. Explain the roles of filters, pooling layers, flatten layers, and fully connected layers.
4. **CNN Activation Visualization.** Visualize feature maps after the first and second convolutional layers of a CNN. Explain the meaning of the observed patterns.
5. **Recurrent Neural Network (RNN).** Implement a simple RNN or LSTM for sequence prediction (e.g., temperature or sine wave). Additionally, compare the results with an MLP and explain the differences.
6. **GRU vs. LSTM.** Build two models on the same time series: one using GRU and the other using LSTM. Compare the number of parameters, training speed, and prediction accuracy.
7. **Emotion Recognition from Audio (or Text).** Use an RNN (or 1D CNN) to classify short audio segments or text phrases. Explain the characteristics of sequential data.

MODULAR ASSESSMENT

Sample Test Questions for the Modular Assessment:

1. What is a neural network?
- An optimization method.
- A mathematical model inspired by the structure of the brain.
- A data sorting algorithm.
- A data compression method.

2. What are activation functions used for in neural networks?
- To introduce nonlinearity.
- To optimize computational speed.
- To store neuron weights.
- To regularize the model.

3. What is deep learning?
- Learning on a large volume of data.
- Studying a large number of disciplines.
- Learning using deep neural networks.
- An optimization method for machine learning.

4. Which loss function is commonly used for classification tasks in neural networks?
- Squared distance.
- Cross-entropy.
- MAE (Mean Absolute Error).
- R-squared.

5. What is a Convolutional Neural Network (CNN)?
- A type of network used for time series analysis.
- A network optimized using convolution operations.
- A type of network that is effective for image processing.
- A model for text analysis.

6. What is the purpose of the "Dropout" layer in neural networks?
- Increasing computational speed.
- Randomly disabling some neurons during training to prevent overfitting.
- Improving prediction accuracy.
- Recovering lost data.

7. What is the role of optimizers such as "Adam" or "SGD" in neural network training?
- Visualizing the training process.
- Optimizing neuron weights.
- Generating new data.
- Recovering lost data.

8. What does "backpropagation" represent?
- A method for generating new data.
- An optimization algorithm for updating weights in neural networks.
- A method for visualizing activation functions.
- A method for increasing dataset size.

9. In which case can Recurrent Neural Networks (RNNs) be useful?

- For image analysis.
- For analyzing structured tabular data.
- For learning time series or sequential data.
- For short text classification.

10. What is “transfer learning” in the context of neural networks?

- Using a pre-trained model on a new dataset.
- Transferring data between two networks.
- Changing the activation function.
- A method for evaluating model accuracy.

Appendix C

RATING-BASED ASSESSMENT SYSTEM OF LEARNING OUTCOMES
for the credit module
NEURAL NETWORKS
of the first (Bachelor's) level of higher education

Mode of study	***Full-time (Daytime)***

1. Student Rating for the Credit Module

The student's rating for the credit module is composed of points obtained for:

- completion and defense of **10 computer laboratory reports**;
- completion of the **modular control work**;
- completion of the **home assignment (individual project)**;
- **pass/fail examination (final assessment / examination work)**.

2. Criteria for Awarding Points

2.1. Completion and Defense of Computer Practicals

Computer practicals are submitted according to the following schedule; failure to submit and defend them within the specified timeframe results in **0 points** for the respective practical (format: practical number / week of submission and defense): **1/2; 2/4; 3/5; 4/6; 5/7; 6/8; 7/9; 8/10; 9/11; 10/12.**

Completion and defense of each report are evaluated on a **6-point scale** according to the following criteria:

- **6 points**
  The work is completed without errors and in full; during the defense, the student demonstrates thorough and solid knowledge of the relevant material. The report is submitted on time and fully complies with formatting requirements.
- **4 points**
  Minor inaccuracies are present; during the defense, the student demonstrates knowledge of the material with minor inaccuracies. The report is submitted on time and complies with formatting requirements.
- **2 points**
  The work contains some errors caused by carelessness or insufficient practical skills; during the defense, the student's answer is incomplete or contains inaccuracies in theoretical questions.
  The report is submitted on time but does not fully comply with formatting requirements.
- **0 points**
  The work contains fundamental errors, incomplete or incorrect calculations, and incomplete or incorrect answers to theoretical questions. The report is not submitted on time and is not defended without a valid reason.

Penalty points: not applied.

2.2. Modular Control Work

The modular control work consists of **10 test questions**.
Each question is evaluated as follows:

- **Correct answer** – 1 point
- **Incorrect answer** – 0 points

The modular control work is graded on a **10-point scale**:

- **Excellent** (at least 90% of the required information) – **10–9 points**
- **Good** (at least 75% of the required information) – **8–7 points**
- **Satisfactory** (at least 60% of the required information) – **6–5 points**
- **Unsatisfactory** (does not meet the "Satisfactory" requirements) – **0 points**

2.3. Home Assignment (Individual Project, HA)

The home assignment consists of **two components**:

- content of the work (3 criteria);
- formatting and defense of the work.

There are **5 evaluation criteria**, each worth **6 points**.
The maximum score is **30 points (6 × 5)**.

Component I. Content

The task involves developing procedures, algorithms, and deep learning models in **Python** using the **TensorFlow/Keras** framework to solve a problem based on a given dataset.
In addition to the program code, the student must provide:

- an explanatory note with **time complexity analysis**;
- a **block diagram (flowchart)**;
- **testing results** for various input parameters.

Content evaluation criteria:

1. Functionality of the program according to the individual assignment.
2. Algorithmic solution consistent with the chosen method, including a flowchart description.
3. Time complexity analysis of the algorithm.

Evaluation of each criterion:

- requirements fully met – **6 points**;
- requirements met with remarks – **5 points**;
- requirements partially met – **4 points**;
- requirements not met – **0 points**.

Component II. Documentation

4. Formatting of external program documentation, description of the algorithm, and conclusions in accordance with general scientific and technical documentation standards.

Evaluation:

- requirements fully met – **6 points**;
- requirements met with remarks – **5 points**;
- requirements partially met – **4 points**;
- requirements not met – **0 points**.

Component III. Defense

5. Defense of the home assignment evaluates the student's understanding of the program implementation, the level of independent work, and comprehension of the assigned task.

Evaluation:

- requirements fully met – **6 points**;
- requirements met with remarks – **5 points**;
- requirements partially met – **4 points**;
- requirements not met – **0 points**.

Penalty points: not applied.

2.4. Bonus Points (maximum 10 points)

- Participation in a faculty-level olympiad in the discipline – **6 points**;
- Modernization of computer practicals – **8 points**;
- Completion of tasks aimed at improving didactic materials of the discipline – **8 points**.

2.5. Final Assessment (Pass/Fail Examination)

The final assessment is conducted in the form of a **final examination (examination work)**.

According to clauses 3.8–3.10 and 3.12 of the Regulations (https://osvita.kpi.ua/node/37):

1. The final rating for the discipline is announced to the student during the examination session in **Week 16**.
2. Students who meet all admission requirements and obtain **60 points or more** receive the final rating **without taking the examination work**.
3. Students who meet all admission requirements but obtain **less than 60 points**, as well as those wishing to improve their rating, must complete the **examination work**, which is graded on a **100-point scale**.
4. If a student taking the examination to improve their rating receives a lower score than their current rating, the **current rating is retained**.

The credit test consists of **two variants**.

Variant 1

For students who:

- fulfilled all admission requirements,
- completed all parts of the modular assessment,
- defended all computer practical reports,

- but scored less than 60 points or wish to improve their rating.

Maximum score: 100 points

Component	**Points**
Section I. Introduction to Neural Networks	35
Section II. Neural Network Architectures	35
Home Assignment (session score)	30

Assessment criteria for one exam question:

- **30–35 points** – complete answer (≥90% of required information), correct pseudocode and solution algorithm
- **20–25 points** – sufficiently complete answer (≥60%)
- **10–15 points** – incomplete answer (≥60%)
- **0 points** – incorrect or missing answer (<60%)

Variant 2

For students who:

- fulfilled admission requirements,
- but did not complete all parts of the modular assessment and/or did not defend all practical reports **without valid reasons**, resulting in 0 points (clauses 3.1–3.3 of the Regulations).

Maximum score: 100 points

Component	**Points**
Section I. Fundamentals of Neural Networks	25
Section II. Neural Network Architectures	25
Test task or interview for missed modular parts	20
Home Assignment (session score)	30

Assessment criteria for test/interview:

- **12–20 points** – correct answers (≥60%)
- **0 points** – missing answers or <60% correct

Assessment criteria for one exam question:

- **20–25 points** – complete answer (≥90%)
- **10–15 points** – sufficiently complete answer (≥75%)
- **5–8 points** – incomplete answer (≥60%)
- **0 points** – incorrect or missing answer (<60%)

Appeal Procedure

Detailed assessment criteria are defined in the **Regulation on the Rating System for the Discipline** (Appendix C to the syllabus). A student may appeal the instructor's grade by submitting a written complaint **no later than the next day** after receiving the grade. Appeals are reviewed according to university-established procedures.

Admission Requirements for Semester Assessment

Timely submission and defense of **all Computer Practical Reports** and the **Home Assignment**.

Table: Conversion of Rating Scores to University Grades

Points	**Grade**
100–95	Excellent
94–85	Very Good
84–75	Good
74–65	Satisfactory
64–60	Sufficient
< 60	Unsatisfactory
Admission requirements not met	Not Admitted

Marks in the Semester Record

- **Not Admitted** – failure to meet admission requirements (late submission or defense of reports or HA)
- **Removed** – violation of academic integrity or ethical norms

Absent – student was admitted but did not attend the credit test

Appendix D

Recommended Topics for the Home Assignment

Within the course, students are recommended to complete an individual semester assignment in the form of a home assignment (HA).

The main objective of the home assignment is to solve a specified practical learning task, namely computer modeling of biological systems and decision making, using the course material studied during lectures and computer practicals, as well as independently studied theoretical material, with the mandatory application of the course content.

To achieve this objective, the student must complete the following tasks:

- Analyze the assigned task, select a programming language, and develop an application software package that implements an algorithm for solving the given problem.
- Implement the software modules of the model (depending on the nature of the problem being solved).
- Prepare a report.

Problem Type
1. **Development of a Neural Network for Handwritten Text Recognition** Application of convolutional neural networks for processing handwritten input images.
2. **Neural Network for Object Detection in Video** Use of YOLO, SSD, or Faster R-CNN for detecting moving objects.
3. **Development of a Neural Network–Based Recommendation System** Prediction of user interests based on viewing or interaction history.
4. **Autoencoders for Transaction Anomaly Detection** Detection of fraudulent transactions in banking operations.
5. **Text Generation Using Sequential Models** Application of LSTM or Transformer networks to generate original text content.
6. **Development of a Neural Network for Medical Image Segmentation** Partitioning medical images into meaningful segments to support diagnostic tasks.
7. **Use of Neural Networks for Music Generation** Generation of new musical compositions based on training data.
8. **Weather Forecasting Using Neural Networks** Analysis of meteorological data to predict weather conditions.
9. **Development of a Real-Time Neural Network–Based Translation System** Use of attention mechanisms and Transformer networks for real-time language translation.
10. **Simulation of Natural Processes Using GANs (Generative Adversarial Networks)** Creation of virtual landscapes, plants, or living organisms.

Appendix D1

METHODOLOGICAL GUIDELINES
for preparing the **Home Assignment**

for the academic discipline
NEURAL NETWORKS

of the **first (Bachelor's) level of higher education**,
degree: **Bachelor**

Specialty	***163 Biomedical Engineering***
Educational Program (EPP / ESP)	***Medical Engineering*** (назва)
Mode of Study	***Full-time (Daytime)***

PREPARED BY:

Associate Professor at the Department of Biomedical Cybernetics, PhD in Physical and Mathematical Sciences, Associate Professor, Illia V. Fedorin
(position, academic degree, academic title, full name)

Kyiv 2024

I. General Requirements for the Home Assignment

General Requirements for the Home Assignment

When selecting a topic for the home assignment from the list provided in **Appendix D**, students should primarily be guided by their **own academic and research interests**. Students may also propose their **own home assignment topics**, provided they are closely related to the content of the academic discipline.

General Recommendations for the Home Assignment

- **Language:** state (Ukrainian).
- **Style:** academic (scientific).

Formatting Requirements

Length: 20–25 pages (from the introduction to the list of references).

- **Page format:** A4.
- **Font:** Times New Roman, 14 pt.
- **Line spacing:** 1.5.
- **Margins:** left – 25 mm, right – 10 mm, top and bottom – 20 mm.
- **Simple outline structure.**
- **All handwritten signatures in the paper must be made in blue ink only.**

Structure of the Home Assignment

The paper consists of the following sections:

- title page;
- assignment description;
- abstract;
- table of contents;
- introduction;
- main body;
- general conclusions;
- list of references and literature;
- appendices.

Title Page

The title page must be prepared according to the template provided in **Appendix D2** of the methodological guidelines. The page number is **not indicated** on the title page.

Table of Contents

The table of contents includes a list of sections and subsections with corresponding page numbers.

Introduction

The introduction should reflect the **relevance of the individual assignment**, including:

- justification of the task based on national and international scientific and technical literature;
- justification of the relevance of the selected topic and the proposed solutions.

Abstract

The abstract briefly presents the **general characteristics and main content** of the individual assignment and includes:

1. Information on the volume of the paper, number of figures, tables, appendices, and bibliographic entries in the reference list;
2. The purpose of the assignment, applied methods, and obtained results;
3. A list of **keywords** (no more than 10).

Main Body

Before writing the main body, the titles of sections and subsections must be defined in accordance with the basic requirements for the home assignment.
The content and results should be presented **clearly, logically, and argumentatively**, avoiding vague wording, unsupported statements, and tautology.

This section should describe:

- the methods used to complete the assignment;
- the structure of the work (input data, implementation stages, and final results).

The text may be accompanied by **illustrations** that help clarify the objectives and tasks of the assignment.

General Conclusions

The conclusions should briefly summarize, preferably in the form of concise statements or theses:

- what was accomplished during the assignment;
- the conclusions reached by the student;
- practical recommendations for improving specific aspects of the study.

List of References and Literature

The list of references may be arranged in one of the following ways:

- in the order of appearance of references in the text (recommended);
- in alphabetical order of authors' surnames or titles;
- in chronological order.

The reference list must be formatted according to **DSTU 8302:2015** (*Information and Documentation. Bibliographic Reference. General Requirements and Rules for Compilation*) or according to one of the international citation styles:

- MLA (Modern Language Association);
- APA (American Psychological Association);
- Chicago/Turabian;
- Harvard;
- Vancouver.

Appendices

Appendices contain **illustrative, graphical, computational, and other supplementary materials**.

II. General Formatting Requirements for the Textual Part of the Home Assignment

General Formatting Requirements for the Textual Part of the Home Assignment

Pages of the home assignment must be **numbered**. The **title page** is considered the first page, but the page number is **not displayed** on it. Page numbering begins on the **"Table of Contents"** page. The page number is placed in the **upper right corner** of the page **without a period**.

Sections

1. Headings of the structural parts of the paper — **"TABLE OF CONTENTS," "INTRODUCTION," "CHAPTER," "GENERAL CONCLUSIONS," "APPENDICES," "LIST OF REFERENCES"** — are printed in **uppercase letters** and **centered** on the page.

   Each of these sections starts on a **new page**. Word breaks and underlining in headings are **not allowed**. Structural parts such as the table of contents, introduction, conclusions, and list of references **do not have serial numbers**. *(It is not allowed to write, for example: "1. INTRODUCTION" or "Chapter 6. CONCLUSIONS".)*

2. The **chapter number** is placed after the word **"CHAPTER"**, without a period. The chapter title is printed on the **next line**, using a **non-breaking line break** (keyboard combination **Enter + Shift**).

Subsections and Items

1. **Subsection headings** are printed in **lowercase letters** (with the first letter capitalized), starting with an **indentation**. No period is placed at the end of the heading. If a heading consists of two or more sentences, they are separated by a period.

   Subsections are numbered within each chapter. The subsection number consists of the **chapter number and the subsection number**, separated by a period. A period is placed at the end of the subsection number, for example: **"2.3."** (the third subsection of Chapter 2). The subsection title follows on the **same line**.

2. **Item headings** are printed in lowercase letters (with the first letter capitalized), starting with an indentation. Items are numbered within each subsection. The item number consists of the **chapter number, subsection number, and item number**, separated by periods. A period is placed at the end of the number, for example: **"1.3.2."** (the second item of the third subsection of Chapter 1). The item heading follows on the **same line**.
3. An **additional line spacing** should be inserted between the heading (except for item headings) and the main text.

Example

РОЗДІЛ 1

НАЗВА РОЗДІЛУ

1.1. Назва підрозділу

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Suspendisse sit amet diam risus. Donec posuere nisl diam, vel suscipit eros ultrices quis. Cras viverra ut est et euismod. Pellentesque bibendum quis erat et mollis.

1.2. Назва підрозділу

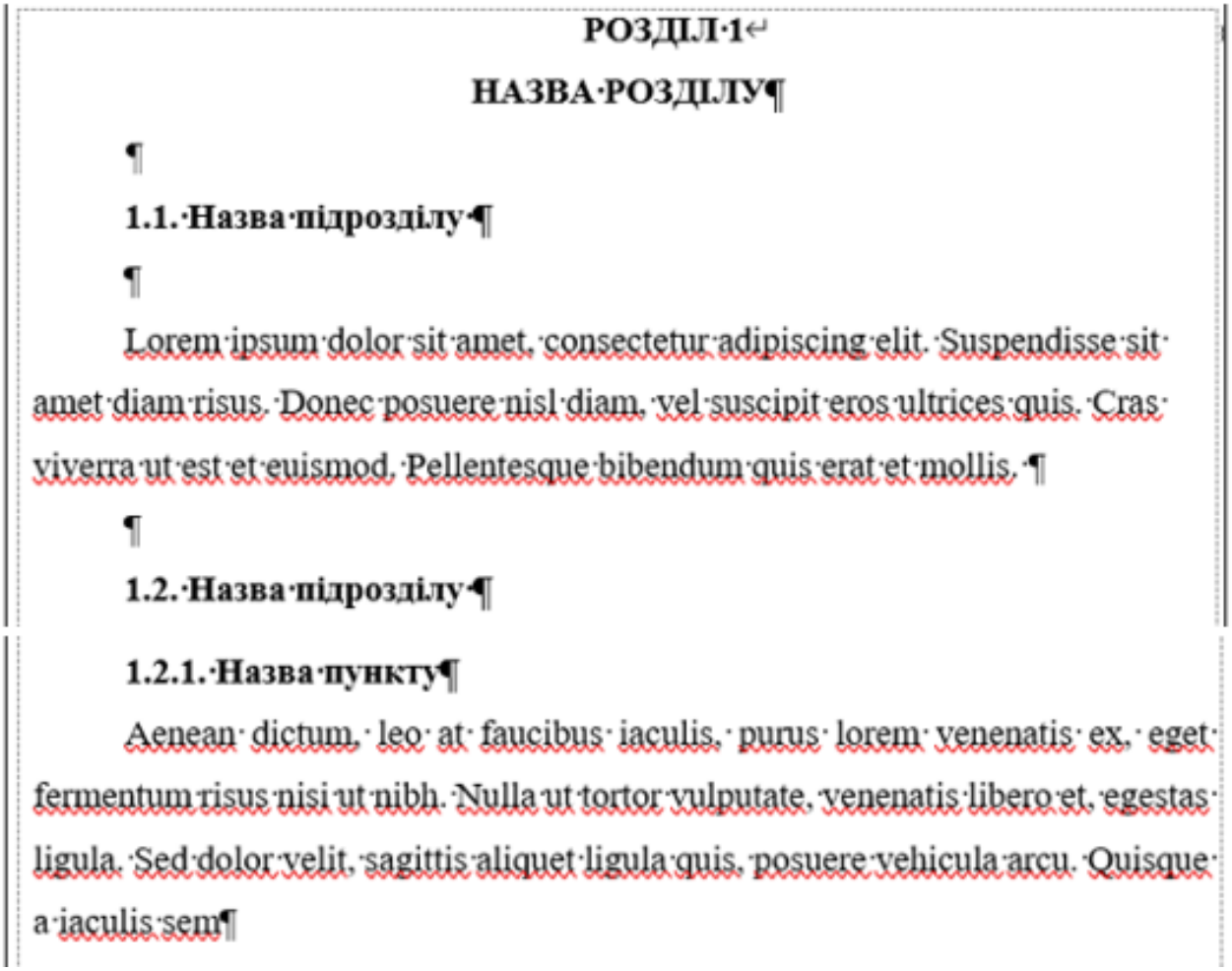
Nullam aliquam molestie accumsan. Praesent egestas nisi dolor, id finibus leo dapibus vehicula. Sed rutrum vestibulum arcu, eu ornare sapien rhoncus non. Integer at lorem metus..

1.2.1. Назва пункту

Aenean dictum, leo at faucibus iaculis, purus lorem venenatis ex, eget fermentum risus nisi ut nibh. Nulla ut tortor vulputate, venenatis libero et, egestas ligula. Sed dolor velit, sagittis aliquet ligula quis, posuere vehicula arcu. Quisque a iaculis sem

..

or



Figures

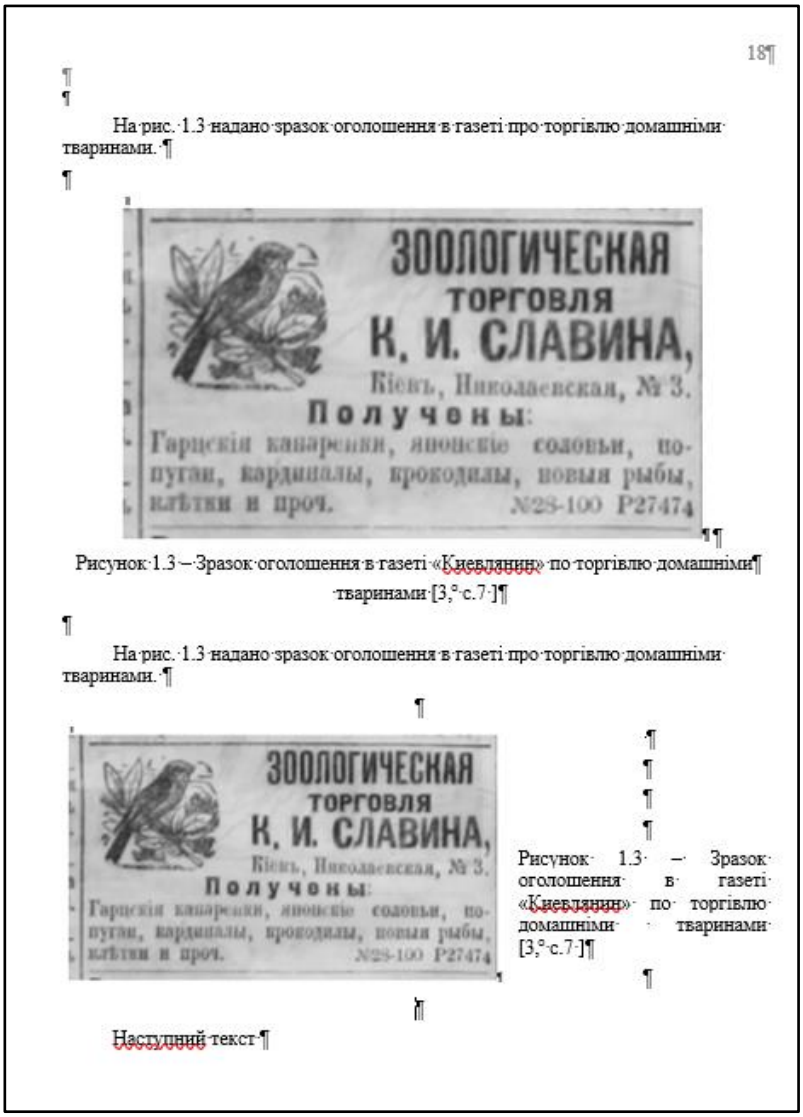
1. Illustrations are labeled with the word **"Figure"** and numbered consecutively. A figure must be placed **immediately after the paragraph** in which it is first mentioned. The **figure caption** is placed **below the figure** (centered) or **to the right of the figure**.
2. In the text where the topic related to the illustration is discussed and where the reader needs to be referred to it, a reference is provided in one of the following forms: "(Fig. 3.1)" or phrases such as "…as shown in Fig. 3.1" or "…as can be seen in Fig. 3.1".
3. The figure caption follows the format:

   "Figure [chapter number].[figure number] – Figure title"

   Example: **Figure 1.3 – Outline map of the territory of Ukraine in the 10th century.**

4. An **additional line spacing** should be inserted **between the text and the figure**, as well as **between the figure caption and the text following the figure**.

Example:



General Rules for Citation and Referencing of Sources Used

The student must **mandatory reference the authors and sources** from which materials or individual results have been borrowed. A quotation in the text should be enclosed in **quotation marks** (“ ” or « »).

When using ideas or developments that also belong to **co-authors** with whom scientific works were jointly published, the student must explicitly indicate this fact. If borrowed material is used **without reference to the author and source**, the work **is not credited**.

References to sources and quotations in the text must be formatted in accordance with the current **DSTU 8302:2015** (*Information and Documentation. Bibliographic Reference. General Requirements and Rules for Compilation*) or according to one of the international citation styles:

- MLA (Modern Language Association);
- APA (American Psychological Association);
- Chicago/Turabian;
- Harvard;

- Vancouver.

References to Illustrations and Tables

References to illustrations are indicated by the **serial number of the figure**, for example: **“Fig. 1.2”**.

All tables included in the paper must be referenced in the text. The word **“table”** is abbreviated in the text, for example: **“…in Table 1.2”**.

In repeated references to tables and illustrations, the abbreviated word **“see”** should be used, for example: **“see Table 1.3”**.

References to quotations are indicated briefly in **square brackets**, specifying the source number in the reference list and the page number of the quotation, for example: **“…[quoted text] … [10, p. 355]”.**

Appendices

Appendices (if any) are оформatted as a **continuation of the paper** on subsequent pages and are arranged **in the order in which they are referenced in the text**.

Each appendix must begin on a **new page** and have a **title**, printed at the top of the page in lowercase letters with the first letter capitalized, centered relative to the page text. Above the title, centered on the line, the word **“Appendix ___”** followed by a **capital letter** designating the appendix is printed.

Appendices are labeled sequentially using **capital letters of the Ukrainian alphabet**, excluding the letters **Ґ, Є, І, Ї, Й, О, Ч, ь**, for example: **Appendix А, Appendix В**. A single appendix is labeled **Appendix А**.

Figures and tables placed in appendices are numbered **within each appendix**, for example:

- **Fig. D.1.2** – the second figure of the first section of Appendix D;
- **Table A.1** – the first table of Appendix A.

III. General Requirements for the Presentation

The presentation must contain **at least 7 slides** (excluding the title slide and the “Thank you for your attention” slide):

1. **Slide 1 – Title slide**, indicating the faculty, department, topic of the individual assignment, student group, author, and instructor (supervisor of the individual assignment).
2. **Slide 2 – List of objectives** of the assignment.
3. **Slides 3–5 – Analysis and obtained results** of the assignment.
4. **Slide 6 – Conclusions** based on the principle: *“assigned objective (Slide 2) – completed objective”*.
5. **Slide 7 – “Thank you for your attention.”*

Appendix D2

NATIONAL TECHNICAL UNIVERSITY OF UKRAINE
"IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE"

FACULTY OF BIOMEDICAL ENGINEERING
Department of Biomedical Engineering

HOME ASSIGNMENT	
For the academic discipline	***Neural Networks***

speciality	***163 Biomedical Engineering***
Educational Program (EPP / ESP)	***Medical Engineering***

Topic **XXXXXXXXXXXXXX**
XXXXXXXXXXXXXXXX

Completed by a **Bachelor's degree student**,
___ year of study
Group **BM-X1-mp/mn___**
IVANOV IVAN IVANOVICH

I hereby certify that this work contains
no borrowed material from the works of other authors without appropriate references.

Student _____ **Name SURNAME**
Reviewed by
_____ **Name SURNAME**

Kyiv – 20xx_.

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

Institute (Faculty)	BIOMEDICAL ENGINEERING (full title)
Department	BIOMEDICAL ENGINEERING (full title)

ASSIGNMENT
for the Home Task to the student

MARKOVA ELIZAVETA DMITRIVNA (surname, first name, patronymic)	
1. Topic of the assignment (variant)	***Development of an Automatic Sleep Stage Classifier Based on Photoplethysmography Signals***

2. Submission deadline	***December 5-10, 20XX***
3. Input data	*Photoplethysmography (PPG) signal database recorded during sleep.*
Sleep stage annotations.	
4. Content of the assignment	*Study of methods for non-contact sleep analysis.*
The sleep stage analysis algorithm should consist of: a signal acquisition block; a signal processing and filtering block; a neural network for signal classification; a post-processing block for neural network outputs; a sleep stage analyzer with statistical output.	

5. Assignment issue date September ***20, 20XX.***

Schedule (Calendar Plan)

№ з/п	Stage of the Home Assignment	Deadlines	Notes
1	Assignment issued	September 20-23, 202X	
	Preparation of Chapter 1	by Oct 10, 20XX	
	Preparation of Chapter 2	by Nov 15, 20XX	
	Preparation of Chapter 3	by Dec 10, 20XX	
	Preparation of Chapter 1	Dec 5–12, 20XX	
	Electronic submission for review	by Dec 12, 20XX	
	Submission of the HA documentation package for defense	by Dec 15, 20XX	
	Defense of the Home Assignment	Dec 15–20, 20XX	

Student				**Elizaveta MARKOVA**
		(signature)		(Name, SURNAME)
Supervisor				**Illia Fedorin**
		(signature)		(Name, SURNAME)