National Technical University of Ukraine «IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE»

Department of Biomedical engineering
Faculty of Biomedical engineering

# Course work on the discipline
# ANALOG AND DIGITAL ELECTRONICS -2.
# DIGITAL ELECTRONICS
## Working program of the academic discipline (Syllabus)

| Requisites of the discipline | |
|---|---|
| **Level of high education** | ***First cycle of higher education (bachelor degree)*** |
| **Branch of knowledge** | *16 Chemical and bioengineering* |
| **Specialty** | *163 Biomedical engineering* |
| **Educational program** | *Medical engineering* |
| **Status of the discipline** | *Normative* |
| **Learning form** | *Full-time (day-time)/ Full-time (part-time) /Distance/Mixed* |
| **Semester** | *Third year, spring semesters* |
| **Course scope** | *1 ECTS credits / 30 hours* |
| **Semester control / control measures** | *Defense of course work* |
| **Schedule** | *30 hours - independent work* |
| **Language** | *English* |
| **Information about course supervisor and lecturers** | ***Lecturers:*** *Associate Professor Viktor Zubchuk Зубчук, PhD, e-mail – granyt@i.ua, Viber – 050-381-5763 Senior lecturer Mohammad Delavar Kasmai, PhD, e-mail m.delavar@kpi.ua http://bme.fbmi.kpi.ua/lectors/* |
| **Course placement** | *Google classroom https://do.ipo.kpi.ua/course/view.php?id=422* |

## Curriculum of the discipline

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

***The purpose of the credit module***

*The course work is an integral part of the discipline "Analog and digital circuitry-2 Digital circuitry.*

*The purpose of the course work is to expand and deepen theoretical knowledge in the discipline "Analog and digital circuitry-2 Digital circuitry" and their use in solving professional problems in the field of biomedical engineering. Execution of the course work allows to master the basic skills of research work, develops the ability to learn independently, find, analyze, creatively interpret information from different sources, formulate conclusions, integrate and summarize the acquired knowledge.*

***The subject of the credit module***

*The theme of the course work corresponds to the objectives of the discipline "Analog and digital circuitry-2 Digital Circuitry "is closely related to the practical needs of biomedical engineering and covers the sections" Elements and combination devices of digital electronics "," Digital serial functional*

*units ".*

***The purpose of teaching the discipline***

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

***GC 1 -*** *Ability to apply knowledge in practical situations.*
***GC 2 -*** *Knowledge and understanding of the subject area and understanding of professional activity.*
***GC 6 -*** *Ability to search, process and analyze information from various sources.*
***GC 7 -*** *Ability to generate new ideas (creativity).*
***GC 9*** *- Ability to communicate with representatives of other professional groups of different levels (with experts from other fields of knowledge / types of economic activity)*

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

***PC 2 -*** *Ability to provide engineering expertise in the process of planning, development, evaluation and specification of medical equipment.*
***PC 6 -*** *Ability to effectively use tools and methods for analysis, design, calculation and testing in the development of biomedical products and services.*
***PC 13 -*** *Ability to ensure and monitor compliance with safety and biomedical ethics when working with medical equipment.*

***The program learning outcomes*** *after studying the discipline "Analog and digital circuitry" are (OPP put into effect by the Order of the Rector NON / 89/2021 from 19.04.2021):*

***PLO 1 -*** *Understanding of fundamental-applied, medical-physical and bioengineering bases of technologies and equipment for research of processes of a human body.*
***PLO 2 -*** *Possession of engineering methods of calculation of elements of devices and systems of medical appointment and a choice of classical and newest constructional materials.*
***PLO 24 -*** *Apply knowledge of the basics of mathematics, physics and biophysics, bioengineering, chemistry, engineering graphics, mechanics, resistance and strength of materials, properties of gases and liquids, electronics, computer science, obtaining and analyzing signals and images, automatic control, systems analysis and decision making methods needed to solve the problems of biomedical engineering.*
***PLO 45 -*** *Improving the technical elements of medical devices and systems and medical devices in the process of professional activity.*

## 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 "Analog and digital circuitry-2 Digital circuitry" refers to the cycle of professional training and has an interdisciplinary nature. It integrates according to its subject knowledge from other disciplines: "Introduction to the profession", "Fundamentals of Informatics", "Fundamentals of Discrete Mathematics", "Electrical Engineering and Electronics". According to the structural and logical scheme of the training program, the discipline "Analog and digital circuitry-2. "Digital Circuitry" is the basis for the study of disciplines "Microprocessor Engineering", "Biomedical devices, apparatus and complexes", "Devices for monitoring physiological parameters of man", preparation of theses in the specialty and in further practical work in the specialty.*

## 3. The content of the discipline

*The content of the course work covers two sections of the discipline "Analog and digital circuitry-2. Digital circuitry ":*

***Section 1. Elements and combination devices of digital electronics***

*Subject 1.1. Logic switches; Mathematical apparatus of digital circuitry. Diode switches. Logic circuits on diodes.*
*Subject 1.2. . Logic switches; Switches by bipolar transistors.*
*Switches by Schottky transistors. Switches by unipolar transistors*
*Subject 1.3. Logic elements in DTL, TTL technology: Diode-transistor logic elements (LE). Basic LE NAND. Elements NOR, AND-OR-NOT. Typical parameters DTL, TTL.*
*Subject 1.4. Logic elements in $I^2L$, CMOS technology: LE by MOS and CMOS transistors. LE NAND, NOR. Implementation of PDNF, PCNF by CMOS transistors. Typical parameters of LE by CMOS-transistors.*
*Subject 1.5. Code Converters (CC): CC Synthesis. Examples of CC implementation in the given bases of LE.*
*Subject 1.6. Encoders and decoders: encoders, priority encoders.*
*Decoders - linear, pyramidal, matrix. Minimization of incomplete decoders. Synthesis of CC based on the decoder-encoder system.*
*Subject 1.7Multiplexers and demultiplexers: Gating, use of decoders in them. Analog multiplexer-demultiplexer. Combination shift devices on multiplexers.*
*Subject 1.8. Arithmetic devices: Semi-adders. Full adders. Subtractors. Subtractor adders.*
*Subject 1.9. Arithmetic devices: Binary-decimal adder. Multi-bit adders with sequential transfer. Multi-bit adders with accelerated transfer. Combination multipliers.*
*Subject 1.10. Digital comparators (DC): Principles of construction of single-digit and multi-digit DC. Binary subtractor comparators. Sectioned multi-bit comparators.*

***Section 2. Digital sequential functional nodes***

*Subject 2.1. Asynchronous and synchronous triggers: Asynchronous and transparent synchronous RS-triggers. Varieties of RS-flip-flops (R-, S-, E-flip-flops). RS-triggers such as "latch" and MS.*
*Subject 2.2. Asynchronous and synchronous triggers: D-triggers such as "latch" and MS. Universal JK-triggers such as "latches" and MS. Varieties of T-flip-flops.*
*Subject 2.3. Registers: Parallel registers. Sliding registers. Reversible shift registers. Ring registers. Register - "Johnson's counter".*
*Subject 2.4. Asynchronous counters: Asynchronous and synchronous counters. Reversible counters. Frequency dividers.*
*Subject 2.5. Synchronous counters: Binary-decimal counters. Counters with controlled enumeration ratio.*
*Subject 2.6. Pulse devices: Pulse edge detectors. Pulse expanders. Trigger pulse generators.*
*Subject 2.7. Pulse generators: Single Pulse generators by logic elements NAND, NOR and by operational amplifiers.*
*Subject 2.8. Digital-to-analog converters (DACs): DACs based on analog adder, resistive structure R-2R, current switches.*
*Subject 2.9. Analog-to-digital converters (ADC): ADC serial deployment. ADC tracking deployment. Bit-by-bit balancing ADC.*

*Subject 2.10. Analog-to-digital converters (ADC) ADC with double integration. Parallel ADCs. Conveyor ADC.*

*Students according to their variant choose calculation schemes and initial data to them.*

*The course work aims to develop analytical and creative abilities of students in the use of analog and digital functional units in biomedical devices for diagnostic and therapeutic purposes.*

| Subject | Program learning outcomes | The main tasks | |
|---|---|---|---|
| | | Control measure | Deadline |
| Course work | PLO 1<br>PLO 2<br>PLO 24<br>PLO 45 | Registration and submission of work for verification | 17th week |
| Course work | PLO 1<br>PLO 2<br>PLO 24<br>PLO 45 | Presentation and defense of the CW | 18th week |

*Approximate list of topics (source options):*

| n | Subject | Technology* | Parameters * |
|---|---|---|---|
| 1. | Digital heart rate monitor | | |
| 2. | Therapeutic magnetic field generator | | |
| 3. | Electronic simulator of PQRST-complex | | |
| 4. | Device for electrospark therapy | | |
| 5. | Digital biopotential meter | | |
| 6. | Digital timer of medical procedures | | |
| 7. | Medical digital temperature meter | | |
| 8. | Multi-channel EEG recorder | | |
| 9. | Device for measuring the I – V characteristics of BAP | | |
| 10. | Digital humidity meter BAP | | |
| 11. | Electronic stereo phonendoscope | | |
| 12. | Pulse generator for BAP stimulation | | |
| 13. | Electronic EHF stimulator BAP | | |
| 14. | Digital BAP resistance meter | | |
| 15. | Generator for laser acupuncture | | |
| 16. | Device for bioresonance therapy | | |
| 17. | Device for recording phonocardiograms | | |
| 18. | Digital radioactivity meter | | |
| 19. | Digital radiation dose meter | | |
| 20. | Digital gas concentration meter | | |
| 21. | Device for ECG recording | | |
| 22. | Digital blood pressure monitor | | |
| 23. | Digital oxygen saturation meter | | |
| 24. | Device for recording pulse waves | | |
| 25. | Digital electronic spirometer | | |
| 26. | Generator for darsonvalization of the body | | |
| 27. | Device for acoustic therapy | | |

| n | Subject | Technology* | Parameters * |
|---|---|---|---|
| 28. | Device for thermopuncture | | |
| 29. | Bioelectricity radiation recorder | | |
| 30. | Phase detector for processing MRI signals | | |
| 31. | Pulse generator for electropuncture | | |
| 32. | UHF feedback therapy | | |
| 33. | Pulse generator for ultrasound ultrasound | | |

** - is determined by the teacher when issuing the task on the CW.*

*It is possible to determine the topic of the course work at the suggestion of the student and the coordination of the topic by the teacher.*

*Students in coordination with the teacher choose the functional and basic scheme. A thorough analysis of the experience of development of devices for the purpose is made, the functional structure of the device is substantiated and the schematic diagrams are selected (developed). The following issues needed to solve:*

*1. Analyze the state and main directions of solving the problem.*

*2. Compare the parameters of industrial designs of relevant devices, their advantages and disadvantages.*

*3. Determine the main parameters of modern samples.*

*4. Develop a schematic diagram according to the selected structure of the device.*

*5. Carry out the necessary calculations of the device components.*

*6. Carry out simulation of the device in the Workbench environment.*

*7. Document time diagrams confirming the compliance of the work with the calculations.*

*The results obtained must be presented in the form of an explanatory note.*

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

*The title page is followed by a detailed plan (content) of the course work, which should highlight the introduction, 3-4 sections of the main content, their sections, 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 volume of course work depending on the chosen topic can vary from 30 to 40 pages of the main text (in agreement with the teacher). The scope of the course work is determined by the student's ability to briefly and exhaustively reveal the topic: the relevance of the topic, current trends and problems, analyze best foreign and Ukrainian practices, draw conclusions and justify their own suggestions and recommendations. An annotation is provided to the course, indicating keywords. Mandatory requirement: clear reference to sources of information. All figures, facts, theories, opinions of scientists, citations should have a reference in the form [2, p.54] (the first digit means the source number in the list of references at the end of the 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 site address on the Internet*

## 4. Training materials and resources

***Basic literature:***


1. *Лебедєв О.М., Ладик О.І. Цифрова техніка. – К.: ІВЦ «Видавництво «Політехніка»», 2004 р.*
2. *Бабич Н.П., Жуков И.А. Компьютерная схемотехника- К.: «МК-Пресс», 2004 г.*
3. *Рябенький В.М., Жуйков В.Я., Гулий В.Д. Цифрова схемотехніка: Навч. посібник. - Львів: «Новий Світ-2000», 2009.-736 с.*
4. *Опадчий Ю.Ф., Глудкин О.П., Гуров А.И. Аналоговая и цифровая электроника. Учебник для вузов. – М.: ХХХ.-2000 г.*
5. *Зубчук В.И., Попов А.А., Фесечко В.А. Комп'ютерна схемотехніка:Методичні вказівки до курсового проектування для студентів напрямків 6.050101 –"Комп'ютерні науки", 6.051003- "Приладобудування". НМУ № Е9/10-225,18.03.2010 р.*


***Additional literature:***


1. *Справочник по цифровой схемотехнике / В.И. Зубчук, В.П. Сигорский, А.Н. Шкуро. – К. «Техніка», 1990 р.*
2. *Титце У., Шенк К. Полупроводниковая схемотехника.- М.: Мир, 1982 г.*
3. *Преснухин Л.Н., Воробьев Н.В., Шишкевич А.А. Расчет элементов цифровых устройств. -М.: Высш. шк. 1982 г.*
4. *Сигорский В.П., Зубчук В.И., Шкуро А.Н. Элементы цифровой схемотехники. Уч. пособие.- Киев УМК ВО 1990 г.*
5. *Зубчук В.И., Шкуро А.Н. Функциональные узлы цифровой схемотехники. Уч. пособие.- Киев УМК ВО 1992 г.*
6. *Зубчук В.І., Захарчук Н.В. «Цифрова схемотехніка» [Електронний ресурс]: практикум з дисципліни «Електроніка» для студентів спеціальностей 6.051402 -«Біомедична інженерія», та 6.051003 «Приладобудування» НТУУ «КПІ» , 2016. – 194 с. – Назва з екрана. – Доступ: http://ela.kpi.ua/handle/123456789/19696.*
7. *Зубчук В.І., Делавар-Касмаі М. Цифрова схемотехніка. Конспект лекцій до вивчення кредитного модуля «Цифрова схемотехніка» [Електронний ресурс]: навчальний посібник для студентів, які навчаються за спеціальностю 163 - Біомедична інженерія, спеціалізацією «Клінічна інженрія». НТУУ «КПІ ім. Ігоря Сікорського» , 2019. – 184 с. – Назва з екрана. – Доступ: http://ela.kpi.ua/handle/ 123456789/27856*


***Information resources***


1. Зубчук В.І., Захарчук Н.В. «Цифрова схемотехніка» [Електронний ресурс]: практикум з дисципліни «Електроніка» для студентів спеціальностей 6.051402 -«Біомедична інженерія», та 6.051003 «Приладобудування» НТУУ «КПІ» , 2016. – 194 с. – Назва з екрана. – Доступ: http://ela.kpi.ua/handle/123456789/19696.
2. Зубчук В.І., Делавар-Касмаі М. Цифрова схемотехніка. Конспект лекцій до вивчення кредитного модуля «Цифрова схемотехніка» [Електронний ресурс]: навчальний посібник для студентів, які навчаються за спеціальностю 163 - Біомедична інженерія, спеціалізацією «Клінічна інженрія». НТУУ «КПІ ім. Ігоря Сікорського» , 2019. – 184 с. – Назва з екрана. – Доступ: http://ela.kpi.ua/handle/ 123456789/27856


## Educational content

## 5. Methods of mastering the discipline (educational component) and independent work of the student (IWS)

*The schedule of course work with an approximate distribution of hours allocated for independent work of students is given in table 1.*

*Table 1*

| *n* | *The name of the stage of the calendar plan* | *IWS, Number of hours* | *Deadline, Week of the semester* |
|---|---|---|---|
| 1. | *Clarify the topic and get the task. Acquaintance with requirements and terms of performance of course work.* | *1* | *1* |
| 2. | *Analytical review of literature sources on the topic of the course work.* | *6* | *2 - 4* |
| 3. | *Writing section 1 of the explanatory note of the CD (up to 20 pages)* | *4* | *5* |
| 4. | *Selection of the functional scheme of the device that implements the task.* | *2* | *6* |
| 5. | *Description of the functioning of the device according to the functional scheme, algorithms and formation of requirements for technical implementation - section 2 of the explanatory note to the CD.* | *4* | *8* |
| 6. | *The choice of the basic electrical circuit of the device that implements the task.* | *2* | *9-10* |
| 7. | *Description of the device according to the schematic diagram with the characteristics and diagrams - section 3 of the explanatory note to the CD.* | *4* | *11* |
| 8. | *Calculating the components of the electrical circuit. Simulation of virtual device operation - section 4 of the explanatory note of the CD.* | *4* | *15* |
| 9. | *Formulation of conclusions. Registration of course work and annotations to it. Submission of work for verification* | *1* | *16* |
| 10. | *Preparing a presentation. Defense of course work* | *2* | *17-18* |
| | ***Hours in general*** | ***30*** | |

**Policy and control**

## 6. Policy of academic discipline (educational component)

***Attending classes***

*Execution of course work is carried out within the framework of independent work of students, for which 30 hours are allotted.*

*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.*

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***Academic integrity***

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

***Norms of ethical behavior***

*Normative principles of behavior of students and employees, defined in sections 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read*

*more: https://kpi.ua/code.*

***Procedure for appealing the results of control measures***

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

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

***Inclusive education***

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

***Distance learning***

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

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

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

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

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

***Learning a foreign language***

*Teaching in English is carried out only for foreign students.*

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

## 7. Monitor and evaluate the system of evaluation of learning outcomes (*Rating System of Evaluation*):

***Calendar control (CC)***

*Calendar control is performed at 8 and 14 weeks of the semester. The condition for obtaining a positive assessment of the calendar control over the educational component of "course work" is the student's compliance with the schedule of course work (see Table 1, paragraphs 5, 8).*

***Semester control***

*The defense of the course work is carried out during the last two weeks of study in the semester, before the examination session.*

*The condition of admission to the defense of the course work is the current rating ≥30 points.*

*To assess the results of the course work, the department creates a commission.*

*The credit grade for the course work is set based on the results of the defense of the work before the commission for the semester control.*

*The examiner and members of the commission, performing semester control, have the right to ask*

*additional questions for a more objective assessment of the course work.*

***Rating system for assessing learning outcomes***

*The rating assessment of the course work has two components:*

*1. The first (starting) characterizes the student's work to perform the tasks provided by the course work and its result - the quality of the explanatory note and graphic material.*

*2. The second component characterizes the quality of defense of the student's term paper.*

*The size of the scale of the starting component is 60 points (table 2), and the protection component - 40 points (Table 3).*

*Table 2*

| *n* | ***The first (starting) component of the course work*** | *Weight points* | *Number* | *Total* |
|---|---|---|---|---|
| | *Timeliness of stages of course work* | *2.5* | *4* | *10* |
| | *Availability and correctness of calculations and modeling.* | *20* | *1* | *20* |
| | *Content and completeness of the topic* | *10* | *1* | *10* |
| | *Quality of graphic material (calculation schemes, tables, figures)* | *10* | *1* | *10* |
| | *Compliance of the course work with the design requirements and regulations.* | *10* | *1* | *10* |
| | ***Total*** | | | ***60*** |

*Table 3*

| *n* | ***The second component of the course work*** | *Weight points* | *Number* | *Total* |
|---|---|---|---|---|
| | | *20* | *1* | *20* |
| | *Degree of mastery of theoretical material and methods of problem solving* | *10* | *1* | *10* |
| | *Substantiation of own opinion, logic and objectivity of conclusions* | *10* | *1* | *10* |
| | ***Total*** | | | ***40*** |

*Criteria for evaluating the two components of the course work are shown in table 4.*

*Table 4*

| *n* | ***Components of the course work*** | *Weight points* | *Evaluation criterion, percentage (%) of required information* | | | |
|---|---|---|---|---|---|---|
| | | | *not less than 90%* | *not less than 75%* | *not less than 60%* | *less than 50%* |
| | *Timeliness of stages of course work* | *10* | *10-9* | *8-7,5* | *7-6* | *5-0* |
| | *Availability and correctness of calculations and modeling.* | *20* | *20-18* | *17-15* | *14-12* | *11-0* |
| | *Content and completeness of the topic* | *10* | *10-9* | *8-7,5* | *7-6* | *5-0* |
| | *Quality of graphic material (calculation schemes, tables, figures)* | *10* | *10-9* | *8-7,5* | *7-6* | *5-0* |
| | *Compliance of the course work with the design requirements and regulations.* | *10* | *10-9* | *8-7,5* | *7-6* | *5-0* |
| | *Degree of mastery of theoretical material and methods of problem solving* | *20* | *20-18* | *17-15* | *14-12* | *11-0* |

| | | | | | | |
|---|---|---|---|---|---|---|
| | *Substantiation of own opinion, logic and objectivity of conclusions* | *10* | *10-9* | *8-7,5* | *7-6* | *5-0* |
| | *Quality of report and presentation* | *10* | *10-9* | *8-7,5* | *7-6* | *5-0* |

*The sum of the scores of the two components is transferred to the credit score in accordance with table 5.*

*Table 5. Translation of rating points to grades on a university scale:*

| *Number points* | *Assessment on the university scale* |
|---|---|
| *100-95* | *Perfectly / Відмінно* |
| *94-85* | *Very good / Дуже добре* |
| *84-75* | *Good / Добре* |
| *74-65* | *Satisfactorily / Задовільно* |
| *64-60* | *Enough / Достатньо* |
| *Less 60* | *Unsatisfactorily / Незадовільно* |
| *Admission conditions are not met* | *Not allowed / Не допущено* |

**Additional information on the discipline**

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

***Program learning outcomes (extended form).*** *As a result of course work on the subject " Analog and digital circuitry-2 Digital circuitry " students will be able to:*

| *Learning outcomes* | | *Correspondence of learning outcomes to competencies in Standard of higher education SHE* | |
|---|---|---|---|
| | | *General competencies (soft skills)* | *Special competencies (professional)* |
| *1.* | *Explain the nature of the behavior of mechanical systems using the appropriate theoretical apparatus* | *Knowledge and understanding of the subject area and understanding of professional activity* | *Understand theoretical and practical approaches to the creation and management of medical equipment and medical equipment* |
| *3.* | *Compose and solve algebraic equations of statics and plane motion of mechanical systems in order to determine the reactions of elms and kinematic characteristics* | *Ability to search, process and analyze information from various sources* | *Apply knowledge of the basics of mathematics, natural and engineering sciences at the level required to solve problems of biomedical engineering* |
| *4.* | *Investigate the mechanical motion of objects using the basic theorems of kinematics* | *Ability to conduct research at the appropriate level* | *Knowledge of research methods and techniques used in the design of medical equipment.* |
| *5.* | *Identify, formulate, and solve engineering problems related to the interaction between living and non-living systems.* | *Ability to apply knowledge in practical situations* | *Ability to effectively use tools and methods for analysis, design, calculation and testing in the development of biomedical products and services* |

***Methodical recommendations for writing and registration of course work***

*The course work consists of the following structural elements: title page, assignments for the course work (hereinafter - CW), calendar plan of preparation of the CW, content, introduction, main part, conclusions, list of references, appendices.*

*The title page is the first page of the course work. The title page should have the information provided in the following sequence: name of the ministry, name of the university; name of the faculty; name of department; name of academic discipline; the topic of the course work and its variant; level of higher education; code and name of the specialty; the name of the educational and professional program; surname and name of the student, course, number of the academic group; signatures of the head and members of the commission; the result of protection; year of course work.*

*The title page, on the next page, is followed by a course work, which contains information about: the deadline for the student to complete the work, initial data for work, a list of graphics, the date of the task, a detailed schedule of course work with deadlines for individual stages work.*

*Next is the content of the course work, which distinguishes: introduction, main section with sections (if necessary), conclusions, list of sources used, appendices (if necessary). The contents on the right indicate the page numbers at the beginning of each section. Each section begins on a new page.*

*The introduction of the course work should contain: relevance, purpose and objectives, subject and research methods.*

*The main section provides an analysis of literature sources, problem formulation, calculation schemes and their description, problem solving, tables, graphs, charts, etc. Mandatory requirement - a clear reference to sources of information in this form [2, p. 54] (the first digit means the number of the source in the list of references given at the end of the course work, and the second digit - the page number in this source).*

*Conclusions should contain an assessment of the completeness of the solution of the tasks and the experience gained during the course work.*

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

*Appendices may include: additional diagrams or tables, descriptions of computer programs used in the process of work, etc.).*

*The total amount of course work can vary from 15 to 20 pages of the main text, which depends on the student's ability to briefly and at the same time comprehensively reveal the topic.*

*Registration of course work is carried out in accordance with DSTU 3008: 2015 "Information and documentation. Reports in the field of science and technology. Structure and design rules.*

*An annotation is provided for the course work, with the indication of key words.*

*Course work is evaluated by the following criteria:*

*- Timeliness of stages of course work.*

*- Availability of all items of problem-solving methodology. Sequence and correctness of calculations.*

*- Content and completeness of the topic.*

*- Quality of graphic material (calculation schemes, tables, figures).*

*- Compliance of the course work with the design requirements and regulations.*

*- The degree of mastery of theoretical material and methods of solving the problem;*

*- Consistency and correctness of calculations.*

*- Substantiation of own opinion, logic and objectivity of conclusions;*

*- Quality of presentation and report.*

*Deadline for submission of course work for review: 10 days before the test session. Coursework is not tested for plagiarism, but must meet the requirements of academic integrity.*

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

*The list of questions which are submitted on defense of course work credit, is given in appendix.*

***Work program of the discipline (syllabus):***

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

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

## *Appendix.*

### *Part I*

1. *Explain the use of logic algebra and standard forms of functions.*
2. *Justify the minimization of logical functions. Karnaugh -Weich method.*
3. *Compare diode switches and logic circuits by diodes.*
4. *Evaluate the efficiency of switches by bipolar transistors.*
5. *Write a switch analysis by Schottky transistors.*
6. *Explain the efficiency of switches on unipolar transistors.*
7. *Analyze the diode-transistor (DTL) logic elements (LE).*
8. *Basic LE NAND. DTL-elements NOR, AND-OR-NOT.*
9. *Compare the parameters of the elements DTLSCH. Typical parameters of DTL.*
10. *Write an analysis of transistor-transistor LE (TTL).*
11. *Justify the basic LE NAND. TTL-elements NOR, AND-OR-NOT.*
12. *Explain the LE with a free collector and with three output states.*
13. *Compare the typical parameters of TTL, TTLSCH.*
14. *Analyze the base LE with current supply.*
15. *Evaluate the effectiveness of the elements of integrated injection logic ($I^2L$).*
16. *Justify the implementation of logical functions OR / NOR, AND / NAND.*
17. *Analyze the conjugation of $I^2L$ - elements with TTL.*
18. *Analyze the logic elements on the MOS and CMOS transistors.*
19. *Compare the logical elements NAND, NOR.*
20. *Compare the implementation of MDNF, MCNF by CMOS transistors.*
21. *Analyze buffer amplifiers by CMOS transistors.*
22. *Explain the methods of CMOS LE protection from static electricity.*
23. *Justify the conjugation of CMOS -elements with TTL.*
24. *Compare the typical parameters of CMOS -elements.*
25. *Explain CC synthesis. Examples of CC implementation in the given bases of LE.*
26. *Analyze the schemes of encoders and decoders. Unitary code.*
27. *Write an analysis of priority encoders.*
28. *Compare decoders - linear, pyramida and matrix.*
29. *Explain the minimization of incomplete decoders.*
30. *Justify the synthesis of CC on the basis of the decoder-encoder system.*
31. *Compare multiplexers and demultiplexers.*
32. *Explain the synthesis of multiplexers and demultiplexers.*
33. *Justify gating in decoders.*
34. *Analyze analog multiplexer-demultiplexer.*
35. *Evaluate the efficiency of the shear device on multiplexers.*
36. *Explain the implementation of logic functions by multiplexers*
37. *Analyze the circuit of a half-adders.*
38. *Explain the principle of synthesis of full adders.*
39. *Analyze the circuits of subtractors and adder-subtractors.*
40. *Explain the circuits of a binary-decimal adder.*
41. *Write an analysis of multi-bit adders with sequential transfer.*
42. *Compare multi-bit adders with accelerated transfer.*
43. *Evaluate the effectiveness of combinational multiplier circuits.*
44. *Analyze digital comparators - single-bit and multi-bit.*
45. *Evaluate the efficiency of comparators based on the binary subtractor.*
46. *Evaluate the efficiency of partitioned multi-bit comparators.*

### *Part II*

1. *Implement asynchronous and synchronous RS-flip-flops.*
2. *Compare types of RS-flip-flops (R-, S-, E-flip-flops).*
3. *Analyze RS-triggers such as "latch" and MS.*
4. *Compare D-flip-flops asynchronous and transparent synchronous.*

5. *Analyze D-triggers such as "latch" and MS.*
6. *Explain the operation of D-flip-flops in the counter mode.*
7. *Analyze the universal JK-triggers type "latch".*
8. *Analyze the universal JK-triggers type MS.*
9. *Evaluate the main parameters of the triggers.*
10. *Analyze the circuits of parallel registers.*
11. *Write an analysis of shift registers.*
12. *Compare the schemes of reversible shift registers.*
13. *Analyze ring registers and register - "Johnson counter".*
14. *Analyze asynchronous and synchronous counters.*
15. *Justify reversible counters.*
16. *Explain the synthesis of counters - frequency dividers.*
17. *Analyze binary-decimal counters.*
18. *Evaluate counters with a controlled enumeration factor.*
19. *Explain the synthesis of counters with an arbitrary table of transitions.*
20. *Analyze the detectors of the pulse edges.*
21. *Justify pulse expanders.*
22. *Explain trigger pulse generators by bipolar transistors.*
23. *Evaluate trigger pulse generators on unipolar transistors.*
24. *Analyze trigger pulse generators on logic elements.*
25. *Substantiate the trigger pulse generators by amplifier.*
26. *Explain self-oscillating pulse generators on logic elements.*
27. *Analyze pulse generators on operational amplifiers.*
28. *Substantiate generators and generators of linear AC voltage.*
29. *Explain the DAC based on an analog adder.*
30. *Compare the DAC based on the resistive structure R-2R.*
31. *Evaluate the efficiency of the DAC based on current switches.*
32. *Analyze DAC errors.*
33. *Justify sampling and storage devices.*
34. *Explain ADC unfolding balancing.*
35. *Compare the ADC of the tracking balance.*
36. *Compare the ADC bitwise balancing.*
37. *Analyze ADC parameters with double integration.*
38. *Justify parallel ADCs.*
39. *Explain conveyor parallel ADCs.*
40. *The concept of delta-sigma ADC.*