Національний технічний університет «КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ імені ІГОРЯ СІКОРСЬКОГО»

Емблема кафедри (за наявності)

Кафедра обчислювальної техніки

Computer logic-1. Computer logic
(Syllabus)

Details of the academic discipline

Level of higher education ***First (undergraduate)***

Branch of knowledge	***12 Information Technology***
Specialty	***123 Computer Engineering***
Educational program	***Computer systems and networks***
Discipline status	***Normative***
Form of education	***Daytime***
Year of training, semester	***1st year, fall semester***
Scope of the discipline	***5 credits, 150 hours / Lectures - 36 hours, laboratory - 18 hours, individual work of students - 96 hours***
Semester control/ control measures	***Assessment, calendar control***
Timetable	***According to the schedule for the autumn semester of the current academic year at the address*** rozklad.kpi.ua
Language of teaching	***English***
Information about head of the course / teachers	*Lectures:* Dr. Sci. (Engin.), professor ***Zhabin Valerii Ivanovych***, viz.kpi@gmail.com *Laboratory: phD, Docent* ***Verba Oleksandr Andriiovych***, olverba@gmail.com
Placement of the course	***Lecture material:*** *https://bbb.comsys.kpi.ua/b/*

Program of educational discipline

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

Description of the credit module "Computer logic-1. Computer logic" is the first component of the discipline "Computer logic". The study of this discipline as a whole and the credit module allows students to develop the competencies necessary for solving practical problems of professional activity related to the development and analysis of digital circuits in a given elemental basis on the basis of modern microelectronic technology with the use of automated workplaces designing hardware of computer systems for various purposes. The study of this discipline will allow applicants to acquire important competencies in terms of the use of new approaches to the design of highly efficient computer system hardware, as well as to master new technologies for their construction, including on the basis of programmable logic integrated circuits.

The purpose of studying the credit module "Computer logic-1. Computer logic" is the formation of students' ability to independently develop combinational circuits and digital automata with memory for computer systems of various purposes, to analyze their characteristics, as well as to use modern interactive automated systems for designing digital systems for this purpose.

The subject of the discipline and credit module is mathematical, algorithmic and hardware methods and means of ensuring the processes of synthesis of digital circuits in various elementary bases.

As a result of studying the program component, the student should get the following.

Knowledge:

- trends in the development of science and technology in the field of computer engineering;
- the relationship between the sections of the discipline;
  connection with other disciplines;
- basic terms and definitions;
- basic provisions of the theory of switching functions;
- various algebras of logic (Bull, Pierce, Schaefer, Zhegalkin)
- basic provisions of the theory of digital automata with memory;
- basic methods of synthesizing schemes in various elementary bases;
- basic methods of digital circuit analysis;
- principles of construction of typical circuits of computing equipment.
- methods of comparative analysis of technical solutions;
- methods of finding optimal solutions.

Skills:

- represent switching functions in canonical forms of various algebras;
- carry out minimization of switching functions;
- to obtain operator forms of switching functions for various elementary bases;
- develop combination schemes, evaluate their characteristics;
- to develop algorithms for the functioning of automata with memory, to make their formalized description;
- perform abstract synthesis of automata;
- perform structural synthesis of synchronous and asynchronous automata;
- simulate the operation of operating machines;
- determine the complexity of the hardware implementation and the time of operations.

Experience:

- formulate practical problems in terms of algebra of switching functions, abstract and structural theory of digital automata; choose rational methods of solving them;
- set tasks correctly, give a comparative description of various solutions at the stages of designing digital schemes;
- defend the adopted technical decision in a professional discussion;
- conduct an objective analysis of the effectiveness of adopted technical solutions;
- apply methods of avoiding failures in digital circuits;
- be used to build digital systems of large integrated circuits (ICs), including programmable ones.

The discipline "Computer logic" provides the following competencies and program results of the educational and practical program of the first (bachelor) level of higher education *(ОПП): ФК5, ФК10, ФК11, ФК12, ФК14, ПРН3, ПРН7, ПРН13, ПРН16, ПРН15, ПРН22.*

2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

The discipline "Computer logic" begins to be studied by students in the first year in the autumn semester, that is, it is not based on previous disciplines studied at the university. The necessary initial information is taught in lectures. Students can use the advice of teachers, as well as independently familiarize themselves with the material offered in the recommended literature.

The discipline "Computer logic" allows you to more productively master the knowledge and skills of the disciplines taught after this discipline: ЗО14"Computer electronics", ЗО10 "Discrete Math", ПО6 "Computer Architecture", ПО11 "Computer systems", ПО13 "Algorithms and calculation methods".

3. Credit module content

Chapter 1. Introduction**.**
Topic 1.1. Basic provisions of computer logic.
Chapter 2. Switching functions.
Topic 2.1. Algebras of switching functions.
Topic 2.2. Minimization of switching functions.
Topic 2.3. Decomposition of the switching function. Literature.
Chapter 3. Abstract digital automata.
Topic 3.1. Theory of abstract automata.
Topic 3.2. Synthesis of automata at the abstract level.
Chapter 4. Designing logic circuits in a given elementary basis.
Topic 4.1. The main design tasks.
Topic 4.2. Construction of logic circuits.
Chapter 5. Design of digital automata with memory.
Topic 5.1. Synthesis of automata by the trigger decomposition method. Literature.
Topic 5.2. Synthesis of automata using time functions.
Chapter 6. Typical ***OT*** schemes.
Topic 6.1. Typical combination schemes
Topic 6.2. Typical circuits with memory. Programmable microcircuits.

Educational materials and resources

Basic:

1. Zhabin V.I. Applied theory of digital automata: Tutorial / Zhabin V.I.,Zhukov I.A., Klymenko I.A., Tkachenko V.V. – K.: Publishing house of NAU, 2009. – 364p. (The seal of the Ministry of Education and Science of Ukraine), https://www.twirpx.com/file/590265/; https://campus.kpi.ua/tutor/index.php?mode=mob&show&file=fkdxxqvhrvxobmrvpahp.

2. Computer Arithmetic: Workshop [Electronic resource] : study guide for students of specialty 123 "Computer systems and networks", specializations "Computer systems and networks" and "Programming technologies for computer systems and networks"/ Zhabin V.I., Klymenko I.A., Tkachenko V.V.; National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”. – Electronic text data. – Kyiv : National Technical University of Ukraine “Igor Sikorsky

Kyiv Polytechnic Institute", 2019. – 75p.(The fretboard was provided by the Methodical Council of KPI named after Igor Sikorskyi, protocol No. 5 dated November 15, 2018.). https://ela.kpi.ua/handle/123456789/29526.

3. Zhabin V.I. Digital machines. Practicum / Zhabin V.I., Tkachenko V.V. – K.: VEK+, 2004.– 160p.

4. Matviienko M.P. Computer logic. Tutorial / Matviienko M.P. – Kyiv: Publishing house Lira–K, 2012. – 288p.

Additional:

5. Computer logic. Part 1. Computer logic. Methodical instructions for performing laboratory work for bachelor's degree holders in the educational program "Computer systems and networks" specialty 123 Computer engineering of full-time and part-time study / Composer: V.I.Zhabin, O.A.Verba. – Electronic text data. - NTUU "KPI named after Igor Sikorsky", 2022. - 79 p. (Approved by the Methodical Council of FIOT, protocol No. 10 dated 06/09/2022). http://comsys.kpi.ua.

6. Lupenko S.A. Computer logic. Study guide for universities / S.A. Lupenko, V.V. Pasichnik, E.V. Tysh. - View. "Magnolia", 2017. – 354 p.

7. .Borysenko O.A. Discrete Math. Textbook / O.A. Borysenko. – Sumy: University Book, 2018. – 255 p.

Information resources:

8. Synthesis of combinational circuits. https://studfile.net/preview/6442133/page:2/.

9. Computer logic. https://msn.khnu.km.ua/course/view.php?id=3565.

10. Tools for modeling digital devices. ttps://www.twirpx.com/file/745561/ .

Equipment needed for classes

Lecture classes are held in a classroom equipped with a projector, laboratory classes are held in a computer laboratory.

Educational content

Methods of mastering an educational discipline (educational component)

4. *The structure of the credit module*

Names of sections, topics	Number of hours				
	total	Including			
		lectures.	practical.	laboratory.	individual work of student
semester 1					
Chapter 1. Introduction.	6	2			4
Topic 1.1. Substantive provisions.	6	2			4
Chapter 2. Switching functions.	40	14		8	18
Topic 2.1. Algebras of switching functions.	12	4			8
Topic 2.2. Minimization of switching functions.	16	6		4	6
Topic 2.3. Decomposition of switching functions. Examples of scheme synthesis.	12	4		4	4
Chapter 3. Abstract digital automata.	18	6			12
Topic 3.1. Theory of abstract automata.	10	4			6
Topic 3.2. Synthesis of automata at the abstract level.	8	2			6
Chapter 4. Designing logic circuits in a given elementary basis.	18	4		2	12
Topic 4.1. The main design stages.	6	2			4
Topic 4.2. Construction of logic circuits.	12	2		2	8
Chapter 5. Design of digital automata with memory.	26	4		8	14
Topic 5.1. Synthesis of automata by the trigger decomposition method.	12	2		4	6
Topic 5.2. Synthesis of automata using time functions.	14	2		4	8
Chapter 6. Typical schemes.	22	6			16
Topic 6.1. Typical logic circuits	12	4			8

Topic 6.2. Typical circuits with memory.	10	2			8
Preparation for the test	20				20
Total per semester	150	36	-	18	96

5. Lecture classes

№	The name of the topic of the lecture and a list of main questions (list of didactic tools, references to literature and tasks for individual student work)
1	Chapter 1. Introduction. Topic 1.1. Basic provisions of computer logic. **Lecture 1.** Overview of the development of the theory and applied issues of the use of digital automata. The subject and significance of the discipline "Computer logic" in solving modern problems of computer technology. Course objectives. Place of the course in the development of modern computer hardware and software. Presentation of information in digital computers. Tasks for individual processing: non-traditional presentation of information in digital computers. Literature [1, section A1-1.1].
2	Chapter 2. Switching functions. Topic 2.1. Algebras of switching functions. **Lecture 2.** Basic concepts and definitions. Ways of assigning switching functions. The problem of functional completeness of systems of functions. Tasks for individual processing: examples of functionally complete systems. Literature [1, section A1-1.2, A1-1.10; 4, section 2, p. 31-46].
3	**Lecture 3.** Algebras of switching functions. Analytical presentation of functions in various algebras. Assignment for individual processing: graphical presentation of functions. Literature [1, section A1-1.3 - A1-1.9; 4, chapter 3, p. 61-64].
4	Topic 2.2. Minimization of switching functions. **Lecture 4.** General issues of minimization of Boolean functions. Quine's method. The Quine-McCluskey method. Tasks for individual processing: absolutely minimal forms of functions. Literature [1, section A1-2.1 – A1-2.3; 2, section 3, section 3; 3. Section 4; 4, section 6].
5	**Lecture 5.** The Blake-Poretsky method. Method of Veitch diagrams (Carnot maps). Task for individual processing: transition from the disjunctive normal form of the general form to the perfective conjunctive normal form. Literature [1, section A1-2.6; 3, section 3; 4, chapter 6, p. 101-121].
6	**Lecture 6.** Minimization of systems of Boolean functions. Minimization of conjunctive forms. Nelson's method. Petrik's method. Minimization of partially defined functions. Tasks for individual processing: analysis of methods for machine minimization. Literature [1, section A1-2.6, A1-2.7; 2,

№	The name of the topic of the lecture and a list of main questions (list of didactic tools, references to literature and tasks for individual student work)
7	**Lecture 7.** Minimization of systems of partially defined switching functions. Operators of the form of switching functions. Task: taking into account the elementary basis when forming operator forms. Literature [1, section A1-2.8; 2, section 1, p. 11-15, section 2-3, p. 31-47; 3, section 4, p. 32-39-].
8	Topic 2.3. Decomposition of switching functions. **Lecture 8.** Methods of decomposition of functions. Simple separable decomposition. Shannon decomposition. Examples of scheme synthesis using function decomposition. Task: multivalued logical functions. Literature [1, section A1-2.10;].
9	Chapter 3. Abstract digital automata. Topic 3.1. Theory of abstract automata. **Lecture 9.** Basic concepts and definitions. Methods of assignment of abstract automata. Task: examples of the use of automata in technical systems. Literature [1, section A1-3.1 – A1-3.2; 3, chapter 10-11, p. 87-108; 4, chapter 8, p. 139-142].
10	**Lecture 10.** Mili automaton, Moore automaton. Equivalent transformations of automata. Concept of decomposition of abstract automata. Task: types of elementary automata (triggers). Literature [1, A1-3.1; 4, section 8, p. 143-150].
11	Topic 3.2. Synthesis of automata at the abstract level. **Lecture 11.** Minimization of abstract automata. Construction of graphs and tables of equivalent automata. Task: construction of graphs of trigger transitions. Literature [1, section A1-3.1 – A1-3.2].
12	Chapter 4. Designing logic circuits in a given elementary basis. Topic 4.1. The main design stages. **Lecture 12.** Taking into account the elementary basis when designing schemes. Finding operator forms. Task: property of associativity in different functional bases. Literature [1, section A1-1.9].
13	Topic 4.2. Construction of logic circuits. **Lecture 13**. Taking into account the coefficients of the union at the input and output of elements. Risk of failure in logic circuits, methods of its elimination. Task: filters to eliminate short-term signals. Literature [1, section A1-2.11].

№	The name of the topic of the lecture and a list of main questions (list of didactic tools, references to literature and tasks for individual student work)
14	Chapter 5. Design of digital automata with memory. Topic 5.1. Structural synthesis of automata by the method of composition of triggers. Lecture 14. Methods of structural synthesis of synchronous automata with memory using elementary automata. Coding of states. Selection of element base. Construction of systems of memory excitation functions and automaton outputs. Task: the influence of methods of encoding states on the risk of failure in automata. Literature [1, section A1-3.3 – A1-34].
15	Topic 5.2. Structural synthesis of automata using time functions. Lecture 15. Peculiarities of the synthesis of automata using the method of time functions. Analysis of logic circuits of various types. Task: ensuring the duration of the machine's output signals. Literature [1, section A1-3.5; 2, section 6, p. 68-76].
16	*Chapter 6. Typical schemes of digital technology.* *Topic 6.1. Typical combination schemes* *Lecture 16. Types of typical combinational circuits, their features. Encryptors, decoders, multiplexers, demultiplexers, adders, construction of combination circuits based on typical nodes. Task: methods of accelerating transfers in adders. Literature [1, section A1-4.1 – A1-4.5].*
17	*Lecture 17. varieties of large programmable integrated circuits. Designing combinational circuits using large programmable integrated circuits. Directions of development of the theory and technology of construction of circuits of digital equipment. Task: varieties and characteristics of large integrated circuits without memory. Literature [1, section A1-4.6;].*
18	*Topic 6.2. Typical circuits with memory.* *Lecture 18. The principle of building typical circuits with memory. Triggers, registers, counters, their use in computer circuits. Task: varieties and characteristics of large integrated circuits with memory. Literature [1, section A1-4.7 – A1-4.9; 3, section 7, section 8].*

Laboratory classes

The purpose of the laboratory work is to acquire skills and practical application of logical methods of analysis and synthesis of digital circuits. Laboratory classes can be performed both on specially created laboratory models (stands) and with the use of simulation systems on computers.

№ з/п	Name of laboratory work (computer workshop)	Number of classroom hours
1	Synthesis of switching functions in different algebras (Chapter 2, topic 2.1).	2
2	Minimization of switching functions (Chapter 2, topic 2.2).	4
3	Minimization of systems of switching functions (Chapter 2, topic 2.2).	4
	Minimization of partially defined functions	2
4	Synthesis of digital automata based on triggers (Section 3, topics 3.1, 3.2; section 4, topic 4.2; section 5, topic 5.1).	4
5	Synthesis of automata using the apparatus of time functions (Chapter 5, topic 5.2).	2

6. Individual work

№ з/п	The name of the topic submitted for independent processing	Number of hours
1	Topic 1.1. Basic provisions of computer logic.	4
2	Topic 2.1. Algebras of switching functions.	8
3	Topic 2.2. Minimization of switching functions.	6
4	Topic 2.3. Decomposition of switching functions.	4
5	Topic 3.1. Theory of abstract automata.	6
6	Topic 3.2. Synthesis of automata at the abstract level.	6
7	Topic 4.1. The main design stages.	4
8	Topic 4.2. Construction of logic circuits.	8
9	Topic 5.1. Structural synthesis of automata by the trigger decomposition method.	6
10	Topic 5.2. Structural synthesis of automata using time functions.	8
11	Topic 6.1. Typical combination schemes	8
12	Topic 6.2. Typical circuits with memory.	8

Individual work involves:

- *preparation for lectures;*
- *preparation for laboratory classes;*
- *preparation for the test.*

Policy and control

7. Policy of academic discipline (educational component) *During classes in the academic discipline "Computer logic", students must adhere to certain disciplinary rules:*

- *it is forbidden to be late for classes;*
- *when the teacher enters the classroom, students stand up as a sign of greeting;*
- *extraneous conversations or other noise that interferes with classes are not allowed;*
- *leaving the classroom during the lesson is allowed only with the teacher's permission.*
- *the use of mobile phones and other technical means is not allowed without the teacher's permission.*

8. Types of control and rating system for evaluating learning outcomes

Distribution of study time by types of classes and tasks in the discipline according to the working study plan.

Academic semester	The number of hours according to the curriculum							
	total	lectures	Practical training	Laboratory classes	homework control work	modular control work	individual work	Exam/credit
1	150	36		18			96	Test

9.1. The student's semester rating from the credit module is calculated based on a 100-point scale.

9.2. The semester rating consists of points that the student receives for performing 5 laboratory works. The maximum number of points for each laboratory work is 20.

Points are awarded for:

- timeliness of preparation of the protocol for the laboratory session, completeness of the theoretical task: 0-2 points;

- written colloquium on the subject of laboratory work for admission to the practical part of the work: 0-6 points;

- the correctness of the functioning of the developed models on the software emulator (complex of programs for debugging models): 0-7 points,

- protection of the results obtained in the work, answers to the teacher's theoretical questions, completeness of the work protocol: 0-5 points.

Together, the maximum number of points for laboratory works is 100 points (20 points × 5 lab works = 100 points).

9.3. Calculation of the size of the rating scale (R_c).

The sum of the weighted points of control measures during the semester is: $R = R_C$,

– where R_C is the sum of the weighted points of control measures during the semester, which is equal to 100 points.

9.4. Calendar certification of students (for 8 and 14 weeks of semesters) in the discipline is carried out according to the value of the student's current rating at the time of certification. If the value of this rating is at least 50% of the maximum possible at the time of certification, the student is considered satisfactorily certified. Otherwise, "unsatisfactory" is displayed in the certification information.

9.5. A necessary condition for a student to receive a credit is the completion and defense of all laboratory work with a total of at least 60 points. Otherwise, the student must complete a credit control work. Students who do not have academic debt can also improve their grades by completing credit-based tests. Upon completion of the test, the student's semester rating (Rc) is reset to zero. The report shall include an assessment based on the results of the credit test.

The ticket consists of 4 theoretical and practical questions on the topics of lectures and laboratory work performed during the semester. Each question is evaluated from 0 to 25 points.

Evaluation criteria for each question at four levels:

- correct and meaningful answer - 23-25 points;

- correct answer, incomplete explanations - 19-22 points;

- the answer contains errors - 15-18 points;

- there is no answer or the answer is incorrect - 0 points.

The maximum mark for the test is 100 points.

9.6. Taking into account the received sum of points, the final grade is determined by the following table.

Table 1. Determination of the grade on the university scale

R_c	***rating ECTS***	***Traditional assessment***
95...100	*Perfectly*	*counted*
85...94	*Very well*	*counted*
75...84	*Good*	

65...74	*Satisfactorily*	*counted*
60...64	*Enough*	
R_C < 60	*Unsatisfactorily*	*Not counted*
Laboratory work not performed	*Not allowed*	*Not allowed*

9. Additional information on the discipline (educational component)

List of topics and questions for various types of control and self-control

Presentation of information in digital computers.
Ways of assigning switching functions.
The problem of functional completeness of systems of functions.
Algebras of switching functions.
Analytical presentation of functions in various algebras.
General issues of minimization of Boolean functions. Quine's method. The Quine-McCluskey method. The Blake-Poretskyi method.
Method of Veitch diagrams (Carnot maps).
Minimization of Boolean functions in Peirce and Schaefer algebras.
Minimization of conjunctive forms. Nelson's method. Petrik's method.
Minimization of partially defined functions.
Minimization of systems of switching functions.
Operator forms of switching functions.
Canonical representation of functions in the Zhegalkin algebra.
Is minimization of functions performed in the Zhegalkin algebra.
Methods of decomposition of functions. Simple separable decomposition.
Shannon decomposition.
Ways of setting abstract automata.
Methods of specifying structural automata.
Mili machine, Moore machine. Equivalent transformations of automata.
Concept of decomposition of abstract automata. Minimization of abstract automata.
Construction of graphs and tables of equivalent automata.
Taking into account the elementary basis when designing schemes. Finding operator forms.
Risk of failure in logic circuits, methods of its elimination.
Methods of structural synthesis of synchronous automata with memory using elementary automata.
Methods of structural synthesis of synchronous automata with memory using the theory of time functions.
Types of typical combination schemes, their features. Encrypters, decoders, multiplexers, demultiplexers, adders.
Construction of combination schemes based on typical nodes.
Types of large programmable integrated circuits.
Forms of presentation of function systems for implementation on a programmable logic matrix.

Designing combinational circuits using large programmable integrated circuits. Directions of development of the theory and technology of construction of circuits of digital equipment.
The principle of building typical circuits with memory. Triggers, registers, counters, their use in shemes.
Determination of the main parameters of logic circuits

Methodological recommendations for preparing and conducting laboratory work

Performing laboratory work allows you to expand and consolidate theoretical knowledge of the discipline, master the skills of designing and researching digital circuits. Each laboratory work must be preceded by independent preparation of students, during which they study in detail the description of practical work, relevant sections of the lecture notes and literary sources. In the process of preparation, a report on practical work is drawn up, in which all points of the theoretical task must be reflected, as well as tables, algorithms, schemes, etc. prepared for the experimental part of practical work. Before starting laboratory work, the results of training are checked by the teacher. During such an examination, the student must present the prepared report and answer the control questions. Before the start of the next lesson in the laboratory, the student presents a fully prepared report on the previous work to the teacher. The report should contain brief theoretical information necessary for the performance of the task, answers to control questions, schemes, formulas, algorithms, tables, diagrams, graphs, program code, compiler reports obtained during the performance of the task and in the process of modeling and experimental research of the developed devices, as well as conclusions The student receives credit for the performance of the work after an interview on the topic of the work performed.

Working program of the academic discipline (syllabus):

Folded, Dr. Sci. (Engin.), professor, Zhabin V.

Approved by the Department of Computing (Protocol No. 10 dated 05/25/2022).

Agreed by the methodical commission of FIOT (protocol No. 10 dated 09.06.2022).