Національний технічний університет «КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ імені ІГОРЯ СІКОРСЬКОГО»

Емблема кафедри (за наявності)

Кафедра обчислювальної техніки

Computer logic-2. Computer arithmetic (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, spring semester***
Scope of the discipline	***5 credits, 150 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 educational discipline, its purpose, subject of study and learning outcomes

Credit module "Computer logic-2. Computer Arithmetic" is the second component of the discipline "Computer Logic". The study of this credit module allows students to develop the competencies necessary for solving practical problems of professional activity, regarding the processing of digital information in computer systems.

The purpose of studying the credit module "Computer logic-2. "Computer Arithmetic" is for students to acquire in-depth knowledge of the methods of data presentation in computers and to perform basic arithmetic operations with numbers presented in various formats, as well as to acquire skills and abilities in the application of methods of synthesis of arithmetic devices, to master modern technologies for their development, including, based on programmable logic integrated circuits.

The subject of the credit module is mathematical, algorithmic and hardware methods of performing arithmetic operations, construction of arithmetic devices in various elementary bases, their modeling and research of the main characteristics.

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

Knowledge:

- trends in the development of science and technology in the field of computer engineering;
- interrelationship of sections of the discipline and their connection with other disciplines;
- basic terms and definitions of computer arithmetic;
- number systems and transition from one system to another;
- basic methods of presenting data in computer systems in various formats;
- basic methods of performing fixed-point operations;
- basic methods of performing operations in floating point;
- principles of building means of performing operations in computers.
- methods of comparative analysis of technical solutions;
- methods of finding optimal solutions.

Skill:

- represent numbers in different counting systems;
- perform a transition between different counting systems;
- to submit numbers in machine codes taking into account signs;
- use different languages for describing algorithms and operating devices;
- develop operational schemes and algorithms for performing basic fixed and floating point operations;
- simulate the operation of operating machines;
- determine the complexity of the hardware implementation and the time of operations;
- apply methods of controlling the execution of operations in computers;
- perform a comparative analysis of technical solutions;
- simulate the operation of operating machines;
- determine the complexity of the hardware implementation and the time of operations.

Experience:

- formulation of practical problems in terms of hardware, microprogram and software description languages for data processing;
- choosing rational options for solving data processing problems;
- set tasks correctly, give a comparative description of various solutions at the design stages of digital devices;
- 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;
- using large integrated circuits, including programmable ones, to build computing devices.

The credit module provides the following competencies and program results of the educational and practical program of the first (bachelor) level of higher education : ФК5, ФК10, ФК11, ФК13, ФК15, ПРН3, ПРН7, ПРН13, ПРН15, ПРН16, 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)

When students study the credit module "Computer logic-2. Computer Arithmetic" uses the knowledge gained during the study of ЗО10 "Discrete Mathematics", ЗО11 "Physics", as well as ПО1 of the previous credit module "Computer Logic-1. Computer logic".

Credit module "Computer logic-2. Computer Arithmetic" allows students to more productively master the knowledge and skills of the disciplines taught after this module, namely: ПО6 "Computer Architecture", ПО11 "Computer Systems", ПО13 "Algorithms and Calculation Methods".

3. Credit module content

Chapter 1. Numerical systems.

Topic 1.1. Numerical systems, definitions, classification.

Topic 1.2. Conversion of number systems.

Chapter 2. Presentation of information in computers.

Topic 2.1. Presentation and storage of numbers in computers.

Topic 2.2. Data description languages, algorithms and microalgorithms.

Chapter 3. Operations with a fixed point.

Topic 3.1. One-stroke operations.

Topic 3.2. Operation of multiplication and division of numbers.

Topic 3.3. Ways to speed up operations.

Chapter 4. Operations with floating point.

Topic 4.1. Multiplication and division of floating point numbers.

Topic 4.2. Addition and subtraction of floating point numbers.

Chapter 5. Other data conversion operations.

Topic 5.1. Calculation of functions.

Topic 5.2. Operations in the decimal number system.

Chapter 6. Control of operations in computers.

Topic 6.1. Ways of controlling operations

4. 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. Zhabin V.I. Arithmetic and control devices of digital computers. Tutorial / Zhabin V.I., Zhukov I.A.,Klymenko I.A., Stirenko S.H. – K.: VEK+, 2008. – 176p. (The seal of the Ministry of Education and Science of Ukraine). https://www.twirpx.com/file/1797051/.

3. 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 (1 file: 1.33 MB). – Kyiv : National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, 2019. – 75p. https://ela.kpi.ua/handle/123456789/29523.

4. Melnyk A.O. Computer architecture / Melnyk A.O. – Lutsk; Volyn regional printing house, 2008. – 470p.

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

Additional:

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

7. Korniichuk V.I. Basics of computer arithmetic / Korniichuk V.I., Tarasenko V.P., Tarasenko-Kliatchenko O.V.. – K.: «Korniichuk», 2014. – 170p.

Information resources:

8. Discrete Math. https://studfile.net/preview/6177007/.

9. Arithmetic foundations of informatics. https://sites.google.com/site/lutskschool1yasenchuk/materiali-do-urokiv/moduli/matematicni-osnovi-informatiki

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)

5. *The structure of the credit module*

Names of sections, topics	Number of hours

	total	Including			
		lectured	Practical.	Laboratory.	individual student work
Chapter 1. Numerical systems	20	6		2	12
Topic 1.1 Numerical systems, definitions, classification	8	4			4
Topic 1.2. Conversion of number systems	12	2		2	8
Chapter 2. Presentation of information in computers	18	6			12
Topic 2.1. Presentation of numbers in computers.	12	4			8
Topic 2.2. Data and algorithm description languages.	6	2			4
Chapter 3. Operations with a fixed point	36	8		8	20
Topic 3.1 One-cycle operations	14	2		4	8
Topic 3.2. Operation of multiplication and division of numbers	16	4		4	8
Topic 3.3. Ways to speed up operations.	6	2			4
Chapter 4. Operations with floating point	18	4		4	10
Topic 4.1. Multiplication and division of floating point numbers.	8	2		2	4
Topic 4.2. Addition and subtraction of floating point numbers	10	2		2	6
Chapter 5. Other data conversion operations	26	8		2	16
Topic 5.1. Calculation of functions.	14	4		2	8
Topic 5.2. Operations in the decimal number system.	12	4			8
Chapter 6. Control of operations in computers.	12	4		2	6
Topic 6.1. Methods of controlling operations.	12	4		2	6
Preparation for the test	20				20
Total per semester	150	36		18	96

Lecture classes

№ з/п	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 study)
1	Chapter 1. Numerical systems. Topic 1.1. Numerical systems, definitions, classification. Lecture 1. Definition and classification of number systems. Positional, non-positional, symbolic, redundant, homogeneous, heterogeneous number systems. Systems with coded and non-coded representation of numbers. Task: the concept of the system of residual classes. Literature [1, section B1-1.1; 4, section 2, p. 56-62; 5, section 1, p. 10-22].
2	Lecture 2. Comparative assessment of counting systems and number coding. Properties of codes. Binary-decimal codes. The range and accuracy of numbers in different counting systems. Justification of the choice of the number system and codes for computers. Task: types and properties of binary-decimal codes. Literature [1, section B1-1.1; 4, section 2, p. 56-59].
3	Topic 1.2. Conversion of number systems. Lecture 3. Conversion of numbers from one number system to another. Peculiarities of operations in different counting systems. Task: formation of hyphens when adding numbers in various binary-decimal codes. Literature [1, section B1-1.2; 4, section 2, p. 60-65].
4	Chapter 2. Presentation of information in computers. Topic 2.1. Presentation of numbers in computers. Lecture 4. Forms and formats of presenting numbers. Machine codes (direct, reverse, complementary). Task: use of modified codes. Literature [1, section B1-1.3 – B1-1.4; 4, section 2, p. 60-70].
5	Lecture 5. Representation of numbers with fixed and floating point. Discharge grid. Mantissa, order, characteristic. Task: standards of number formats in personal computers. Literature [1, section B1-1.4; 4, section 2, p. 63-70].
6	Topic 2.2. Data and algorithm description languages. Lecture 6. Languages for describing data transformation algorithms in computers. Linear and graphic diagrams of algorithms. Description of data structures. Operational schemes of data processing. Description of micro operations. Task: features of meaningful and coded algorithms. Literature [1, section B1-2.1].
7	Chapter 3. Operations with a fixed point. Topic 3.1. One-stroke operations. Lecture 7. Algorithms for shifting, adding and subtracting fixed-point numbers. Loss of significance of the result, error of the result. Task: ways to reduce the error of the result. Literature [1, section B1-2.3 – B1-2.4; 4, sections 6.2-6.4].

№ з/п	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 study)
8	Topic 3.2. Fixed-point operation. Lecture 8. Basic methods of multiplying numbers with a fixed point in direct codes. Processing of number signs. Rounding of the result, error of the operation. Multiplication in complementary codes. Task: simulation of operations using node state tables. Literature [1, B1-3.1; 2, section 2.1; 2, section 4.1; 4, section 6.4.4.].
9	Lecture 9. Basic methods of dividing numbers with a fixed point. Processing of operand signs. Rounding of the result, error of the operation. Task: a feature of division in systems with a large basis. Literature [1, section B1-4.1; 2, section 4; 4, section 6.4.5].
10	Topic 3.3. Ways to speed up operations. Lecture 10. Logical and hardware methods of accelerating basic operations. Simultaneous processing of a group of digits. Matrix multiplication schemes, trees of adders. Task: the effect of different methods of accelerating operations on the complexity of devices. Literature [1, section B1-3.2; 2, section 4, p. 87-94].
11	Lecture 11. Schemes of accelerated division. Task: the effect of different methods of accelerating division on the complexity of devices. Literature [1, section B1-3.2].
12	Chapter 4. Operations with floating point. Topic 4.1. Multiplication and division of floating point numbers. Lecture 12. Multiplication and division of floating-point numbers. Processing of mantissas and orders. Rounding and normalization of results. Task: analysis of methods of rounding the result into a binary-decimal code. Literature [1, section B1-61 – B1; 4].
13	Topic 4.2. Addition and subtraction of floating point numbers. Lecture 13. Stages of addition and subtraction of floating point numbers. Determining the difference of number orders, aligning orders, adding/subtracting mantissas, rounding and normalizing the result. Calculation error. Task: peculiarities of operations in systems with a large base. Literature [1, section B1-6.1; 4, section 6.4.6].
14	Chapter 5. Other data conversion operations. Topic 5.1. Calculation of functions. Lecture 14. Methods of calculating functions. Algorithms for calculating functions with fixed and floating point. Task: choosing the bit rate of operands to ensure the specified accuracy of calculations. Literature [1, section B1-5; 4, section 6.5].
15	Topic 5.2. Operations in the decimal number system. Lecture 15. Machine algorithms for converting numbers from the binary system to the decimal system and vice versa for different ways of encoding digits of the decimal system (different binary-decimal codes). Task: tabular ways of converting numbers. Literature [1, section B1-1.5].

№ з/п	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 study)
16	Lecture 16. Arithmetic operations in the decimal number system. Binary-decimal codes. Task: to submit operating diagrams of arithmetic operations in the decimal number system. Literature [3, chapter 5, p. 61-67].
17	Chapter 6. Control of operations in computers. Topic 6.1. Methods of controlling operations. Lecture 17. Ways of controlling the execution of operations. Orthogonal control. Task: tabular methods of controlling operations. Literature [2, section 3.2.3].
18	Lecture 18. Module control during operations management. Task: familiarization with methods of memory control. Literature [2, section 3.2.3].

6. Laboratory classes

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

№ з/п	Name of laboratory work (computer workshop)	Number of classroom hours
1	Study of methods of presenting data and performing single-cycle operations in computers (section 2, topic 2.1, 2.2, section 3. Topic 3.1)	4
2	Design and research of devices for multiplying numbers (chapter 3, topic 3.2)	4
3	Design and research of devices for dividing numbers (chapter 3, topic 3.2)	4
4	Investigation of addition and subtraction operations in binary coded systems (chapter 5, topic 5.2)	2
5	Study of number conversion operations between number systems with different bases (chapter 1, topic 1.2)	4
	Total:	18

7. Individual work of students

Individual work of students includes: preparation for lectures; preparation for laboratory classes; preparation for the exam.

№ з/п	*The name of the topic submitted for independent processing*	*Number hours of individual work*

1	Topic 1.1 Numerical systems, definitions, classification	4
2	Topic 1.2. Conversion of number systems	8
3	Topic 2.1. Presentation of numbers in computers.	8
4	Topic 2.2. Data and algorithm description languages.	4
5	Topic 3.1 One-cycle operations	8
6	Topic 3.2. Operation of multiplication and division of numbers	8
7	Topic 3.3. Ways to speed up operations.	4
8	Topic 4.1. Multiplication and division of floating point numbers.	4
9	Topic 4.2. Addition and subtraction of floating point numbers	6
10	Topic 5.1. Calculation of functions.	8
11	Topic 5.2. Operations in the decimal number system.	8
12	Topic 6.1. Methods of controlling operations.	6
	Preparation for the test	20
	Total:	96

Policy and control

8. 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;
- at the entrance of the teacher, as a sign of greeting, persons studying at KPI named after Igor Sikorsky should stand up;
- 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.

9. 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	Laboratory	homework control work	modular control work	Individual work	Exam
1	150	36		18			96	Exam

9.1. The student's semester rating from the credit module is calculated based on a 100-point scale. The rating consists of the points that the student receives for performing 5 laboratory works $R_Л$ and the exam $R_Е$.

9.2. The maximum number of points for each laboratory work is 12, that is, the maximum number of points $R_Л$=60 (12·5=60).

For each work, points are awarded for:

- timeliness of preparation of the protocol for the laboratory session, completeness of the theoretical task: 0-1 points;

- written colloquium on the subject of laboratory work for admission to the practical part of the work: 0-4 points;

- the correct functioning of the developed models on the software emulator (complex of programs for debugging models): 0-4 points,

- defense of the results obtained in the work, answers to the teacher's theoretical questions, completeness of the work protocol: 0-3 points.

The points that the student will receive during the semester are formed as follows:

$$R_С=R_Л.$$

The maximum value $R_С$ = 60. A student is admitted to the exam if he has completed all laboratory work. At the same time, the sum of points must be at least 60%, that is, at least 36 points. Otherwise, you need to get additional points (it can be an interview with a teacher or an additional task).

9.3. The maximum number of points for the exam is equal $R_Е$=40.

The examination ticket contains 4 tasks (one theoretical and three practical) on the subject of lectures and laboratory work performed during the semester. Each question is evaluated from 0 to 10 points.

Evaluation criteria for each question at four levels:

- correct and meaningful answer - 9-10 points;

- correct answer, incomplete explanations - 6-8 points;

- the answer contains errors - 3-5 points;

- there is no answer or the answer is incorrect - 0 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, the attestation information is marked as "uncertified".

9.5. The number of points per semester is determined by the formula

$$R_C = R_Л.$$

Taking into account the points received for the exam, the total number of points is determined as follows:

$$R_З = R_C + R_E .$$

The final grade for the educational component is determined by the following table.

Determination of the grade on the university scale

$R_З$	**Grade**
95...100	Perfectly
85...94	Very well
75...84	Good
65...74	Satisfactorily
60...64	Enough
$R_C < 60$	Unsatisfactorily
Admission conditions not met	Not allowed

10. Additional information on the discipline (educational component)

List of topics for preparation for laboratory work, examination and self-control

Numerical systems.
Transferring numbers from one number system to another.
Coding of negative numbers in computers.
How are numbers with signs represented in computers?
What machine codes are used to perform addition and subtraction operations?
Explain the rules for representing numbers with signs in different machine circles.
Explain the rules for shifting numbers in forward, reverse, and complementary code.
Explain the rules for adding and subtracting numbers in reverse and complementary code.
How can you detect bit grid overflow when performing operations with machine codes?
Machine number conversion algorithms.
How can microoperations and microalgorithms be submitted?
Forms of presentation of numbers in the computer.

In what form are decimal numbers presented in a computer?
How to determine the number of digits of a binary and binary-decimal number with the same quantitative equivalent?
Explain when, when adding numbers, correction of the result is necessary.
How to determine the necessary correction when adding binary-decimal numbers.
Give the composition of the equipment for building a binary-decimal adder.
What requirements should the binary-decimal code used in the adder satisfy?
What is the essence of the additivity property of the binary-decimal code and what can the absence of such a property in the binary-decimal code lead to?
What is the essence of the weighting property of the binary-decimal code and what can the absence of such a property in the binary-decimal code lead to?
Give examples of binary-decimal codes that have and do not have the additivity property.
Give examples of binary-decimal code that have and do not have the property of weighting.
Give an example of adding signed 4-bit binary-decimal numbers in the given binary-decimal code.
Operations with numbers in fixed-point format.
Adding numbers.
Methods of multiplying numbers given by parallel code.
Describe the four main methods of multiplying numbers.
How to calculate the bit rate of operating device nodes?
What is a microoperation and a microalgorithm of an operation?
Describe the main stages of designing multiplication devices.
How to move from a functional (content) microalgorithm to a structural microalgorithm?
How to determine the required duration of control signals?
How to determine the duration of the multiplication cycle?
Compare the operation time of different multiplication methods.
What additional computing functions do different multiplication methods have?
How to switch from an operational diagram to a functional one?
Ways of multiplying numbers given by a sequential code.
Methods of dividing numbers.
Describe the two main methods of dividing numbers.
How to calculate the bit rate of operating device nodes?
What is a microoperation and a microalgorithm of an operation?
Describe the main stages of designing fission devices.
How to move from a functional (content) microalgorithm to a structural microalgorithm?
How to determine the required duration of control signals?
How to determine the duration of the division cycle, the operation time?
Compare the operation time of different division methods.
In which devices can the microoperations of summation/subtraction and shift be combined? Why is this possible?
Is it possible to reduce the length of the registers of the operating device when implementing the division of numbers according to the second option, if the result must be represented by q digits (q<n)?
How to switch from an operational diagram to a functional one?
The method of calculating the square root.
Operations with numbers in floating point format.
Adding floating point numbers.
Multiplication of floating point numbers.

Division of floating point numbers.
Calculating the floating-point square root.

Methodical recommendations for preparation and performance of 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).