MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TECHNICAL UNIVERSITY
«KHARKIV POLYTECHNIC INSTITUTE»

METHODOLOGICAL INSTRUCTIONS
for independent works
in the «Computer circuitry» academic discipline

for full-time and part-time students
majoring in «Computer Engineering»

Kharkiv 2024

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INTRODUCTION

Computer Circuitry is one of the fundamental disciplines in the field of Computer Engineering. This discipline provides the theoretical and engineering training necessary to perform research and practical work on the research, development and operation of computer hardware, embedded microprocessor and microcontroller systems, computer systems and networks for various purposes (information, medical and industrial).

As a result of studying the discipline, ***students are required to know***: the element base of computers (digital integrated circuits of hard and programmable logic with varying degrees of integration), the principles of building on their basis typical functional units of digital devices of computers, microprocessor and microcontroller systems.

Students are also ***required to be able to***: analyze and develop schemes of digital functional units and devices of computers based on digital chips of hard and programmable logic; measure parameters, find faults, debug and test digital units and devices, as well as operate them; use technical and reference literature, as well as standards in their development and operation.

Students are also ***required to have practical skills*** in the development and analysis of computer hardware, microprocessor and microcontroller systems using modern electronic modeling systems.

It is obvious that such a large amount of knowledge and skills cannot be mastered without regular and rather intense independent work of students both during classroom works and during independent work at home. Independent work develops the skills of continuous self-improvement and the ability to self-education, intensifies search and research activities and provides an opportunity to acquire the knowledge necessary for practical and scientific activities.

1. General information about independent work of students

Independent student work (ISW) is a key component of the educational process, which determines the formation of skills, abilities and knowledge, methods of cognitive activity and provides interest in creative work.

The purpose of independent work is to study additional information presented in the literature, to consolidate the knowledge gained in the discipline being studied. This purpose is achieved by completing homework tasks to study the lecture material, preparing for practical works, individual calculation and graphical tasks (CG) and complex control works (CCW); preparing for and completing reports on laboratory and practical work, etc. The importance of independent work lies in developing students' motivation to study a specific topic using various literary and Internet sources, comparative analysis of the material, and skills in formulating questions for subsequent discussion in the team and with the teacher.

Properly planned and organized independent work of students allows to:

– make the educational process more qualitative and intensive;

– involve students in creative activities;

– implement a differentiated approach to learning;

contributes to:

– creating interest in the chosen profession and mastering its features;

– development of responsibility and organization;

– developing a creative approach to solving non-standard tasks.

Independent work involves various types of individual and group activities of students carried out under the guidance, but without the direct participation of the teacher in the classroom and extracurricular time.

Independent work is a special form of learning on the teacher's task, the completion of which requires a creative approach and the ability to acquire knowledge independently.

The methodological basis of students' independent work is an activity-based approach, when the learning objectives are focused on the formation of skills to solve not only typical but also atypical tasks, when the student needs to show creative activity,

initiative, knowledge, skills and abilities gained in the study of a particular discipline.

The organization of independent work of students in the discipline "Computer Circuitry" is planned and organized by teachers who provide laboratory and practical works, under the guidance of a leading teacher (lecturer).

To provide the effectiveness of students' independent work in the discipline "Computer Circuitry" it is necessary:

– to make a reasonable distribution of the total amount of hours for the study of the discipline into classroom and independent work;

– provide students with the necessary methodological materials to transform the process of independent work into a creative process;

– provide students with plans of practical and laboratory works, methodological developments of topics for independent study, lists and sources (in electronic form) of professional literature;

– use methods of active learning;

– monitor the organization and progress of the SRS and activities that encourage students for the qualitative performance of independent work.

Structurally, the student's independent work can be divided into two parts:

1. Independent work of the student, which is organized by the teacher and clearly described in the educational and methodological materials (methodological instructions and tutorials).

2. Independent work, which the student organizes at his/her discretion, without direct control by the teacher

When studying the discipline "Computer Circuitry" it is recommended to use the following forms of independent work:

1. Note-taking.
2. Abstracting the literature.
3. Annotation of books and articles.
4. Performing search and research tasks.
5. In-depth analysis of scientific and methodological literature.
6. Work with lecture material (studying lecture notes, working in the margins of the

notes with terms, supplementing the notes with materials from the recommended literature and Internet sources).

7. Practical and laboratory works: completing homework in accordance with the teacher's instructions and methodical instructions, obtaining the result.

8. Control work in writing.

Types of independent work:

1. Cognitive activities during the main classroom lessons.

2. Independent work in computer classes and laboratories under the supervision of a teacher.

3. Independent work during scheduled consultations.

4. Extracurricular independent work with literature, electronic resources and Internet sources in the library and at home.

4. Extracurricular independent work on homework of an educational and creative nature (mastering lecture material, preparing for practical and laboratory works, completing calculation and graphical tasks and course projects).

5. Independent mastery of specific training modules offered for self-study by students.

6. Scientific research work.

During independent work on the materials of the discipline under study, the student is required to:

1. Carefully study the material that characterizes the discipline and the subject of self-study. This will allow him/her to clearly understand both the range of issues and problems being studied and the depth of their comprehension.

2. Make a selection of literature sufficient to study the proposed topics.

For the study of the discipline "Computer Circuitry", the list of references is presented, which is recommended. It means that there is always literature that may not be included in this list, but is necessary for the development of the topic.

At the same time, it is important to keep in mind that it is necessary to have different types of literature:

– textbooks, educational and methodological manuals;

– primary sources (including the Internet), which include original works of specialists

in the field of computer circuitry. Primary sources are studied when reading both full texts and individual parts, in which the works are not contained in full, but in the form of selected places, selected thematically;

– monographs, collections of scientific articles, publications in journals, any empirical material;

– reference literature (encyclopedias, dictionaries, state standards, thematic, terminological reference books that reveal the categorical and conceptual apparatus).

3. Good understanding of the main content of a particular topic or issue by studying both recommended and independently found literature. This work also requires constant access to reference literature.

2. Work at lectures

There are several points of view on how to record a lecture. ***One of them is to record the entire lecture (continuous recording).*** However, in this case, it is difficult to distribute attention, because the speed of the teacher's speech is several times faster than the speed of recording. And in an effort to record verbatim, the student does not have time to follow the content of the lecture.

For this discipline, this is exacerbated by the fact that students need to constantly pay attention to illustrations (figures, diagrams, formulas, etc.) on the blackboard or multimedia projector screen. Therefore, this method of recording lectures cannot be considered optimal.

Another point of view is not to record the lecture, but to focus on listening to it. And then at home, write it down from memory, checking the main points with a textbook or study guide. This method can be recognized as effective if you have a textbook or manual and the ability to regularly work independently with the recommended literature and Internet sources.

However, the most effective method within the discipline of Computer Circuitry is the method when conclusions, definitions, formulations of the main provisions, original thoughts of the lecturer, as well as some connecting provisions that allow you to catch the relationship between individual elements of the lecture are noted. And then, at home,

while working independently with a textbook or study guide and various sources of information, supplement the notes taken during the lecture or (preferably) write your own notes.

If lecture notes are available, it is advisable to prepare for the lecture in advance and only monitor the originality of the lecture and make the necessary notes and comments in the notes.

When making lecture notes, it is recommended to follow the following rules:

1. Lectures should be noted down in a notebook, leaving wide margins for further additions when working with recommended literature and Internet sources, comments, and clarifications on questions that have arisen. Each lecture should begin with the date and topic of the lecture.

2. The lecture should be noted from the very beginning, because the introduction may be the key to the entire topic.

3. Elements that need to be reflected as fully as possible and as close to the text as possible:

– definitions, figures, schemes, formulas;

– difficult places;

– facts on which the understanding of the main point depends;

– anything new and unfamiliar;

– data that will be used frequently and is difficult to obtain from other sources.

4. Write as briefly as possible, but without compromising clarity.

The main value of lecture notes is not that they are convenient for preparing for exams. A lecture note is especially valuable if the student expresses his or her attitude to the material, and adds to it data from the recommended literature and Internet sources. It is also advisable to emphasize those places that should be paid attention to during each reading.

3. Work with educational literature

Independent work of students with the recommended literature and Internet sources is not separated from lectures, but thoughtful reading of sources, drafting of abstracts,

preparation of reports based on the read materials contributes to a much deeper understanding of the material of the topic under study. This work also involves students referring to reference literature to clarify specific terms and concepts introduced in the discipline, which contributes to the understanding and consolidation of the lecture material and preparation for laboratory and practical works.

When studying the material in a textbook or study guide, it is necessary to move on to the next question only after the previous one has been correctly clarified, describing in your notebook all the statements and calculations (including those that are omitted in the textbook or were given in the lecture for independent study). Particular attention should be paid to defining the basic concepts of the discipline. It is recommended to highlight the conclusions obtained as a result of studying the material in the summary so that they are better remembered when re-reading the notes.

4. Self-check

After studying a particular topic from notes, a textbook or a study guide, and solving a sufficient number of relevant problems in practical works and on your own, the student is recommended to reproduce from memory the definitions, formulations of the main provisions and answer the control questions on this topic.

If necessary, students should carefully study the material again. Sometimes the lack of mastery of a particular issue becomes clear only when studying further material.

In this case, the student needs to go back and repeat the poorly learned material. An important criterion for mastering theoretical material is the ability to solve problems or pass a test on the material covered.

5. Preparation for practical and laboratory works

In order to maximize the benefits of practical works, it is important to remember that they are based on the material read out in lectures and are usually associated with a detailed review and discussion with students of the issues of the lecture course that are necessary for further work. This is also a kind of quality control of students' independent preparation for practical works.

It should be emphasized that only after the students have mastered the lecture material will it be consolidated in practical works, both as a result of discussion and analysis of the lecture material and by solving typical problems. Under these conditions, the student will not only master the material well, but will also learn how to apply it in practice, and will receive an additional incentive (and this is very important) for active independent study of the lecture.

The main purpose of organizing preparation for practical works is to develop practical skills in solving and implementing classical typical tasks related to the study of the principles of operation, construction, functioning of the main elements and basic units of digital devices of computer systems, and the study of their operation in static and dynamic modes.

In preparation for each lesson, students should refer to the lecture notes on the subject and textbooks. For each lesson, it is necessary to complete an individual homework task, which involves solving a typical problem and modeling the operation of a developed or calculated circuit using electronic circuit modeling programs.

When solving problems independently, students need to justify each stage of the solution based on the theoretical provisions of the discipline. If a student sees several ways to solve a problem (task), he or she should compare them and choose the most rational one. First, it is useful to draw up a brief plan for solving the problem (task). The solution of problem tasks or examples should be presented in detail, accompanied by comments and diagrams, if necessary.

When preparing for laboratory works, it is necessary to follow approximately the same methodology as when preparing for practical works. In this case, before starting laboratory work, the teacher reviews and discusses with students the issues of the lecture course necessary for further work and selectively controls the theoretical knowledge that students have acquired during independent preparation.

For this purpose, the methodological instructions for performing laboratory work should include appropriate control questions. Upon completion of the laboratory work, the student must submit a report on the work performed in the prescribed form.

6. Consultations

If, in the course of independent work on the study of theoretical material or when solving problems and performing laboratory work, a student has questions that cannot be resolved independently, it is necessary to contact the teacher for clarification or guidance. In his/her questions, the student should clearly express what he/she is experiencing difficulties. Consultation should also be sought if there is any doubt about the correctness of the answers to the self-assessment questions.

7. Total hours for studying the discipline and their distribution

The distribution of time for independent work in the discipline "Computer Circuitry" by modules and topics is shown in Table 1.

Table 1 – Structure of the discipline

No. in order	Types of academic works (L, LW, PW, IW)	Number of hours	Semester number (if the discipline is taught in several semesters). Name of topics and questions for each class. Tasks for independent work.	Recommended literature (basic, supportive)
1	2	3	4	5
			Content module 1	
1	L PW LW IW	1 4 2 3	**Introduction.** Subject, purpose and objectives of the discipline, its scientific and engineering content. The place of the discipline in the educational process and professional training of a bachelor. Distribution of study time. Organizational and methodological instructions for studying the discipline (including independent work). Recommended literature. **Topic 1. Digital Logic Gates.** Purpose of logic gates and basic concepts of logical functions. Basic logic gates: graphic symbols, state table. Positive and negative logic. Construction of simple combination circuits on logic gates. Basic technical characteristics and parameters of logic gates. Features of the circuit implementation of logic gates such as TTL, TTLS, CMOS.	1-13

1	2	3	4	5
2	L PW LW IW	2 2 4 3	**Topic 2. Flip-flops.** Purpose and classification of different types of flip-flops. Asynchronous and synchronous RS flip-flops: methods of construction and synchronization. Features of the circuit implementation of D and DV flip-flops (main characteristics). Features of the circuit implementation of JK flip-flops (main characteristics). Features of the circuit implementation of T and TV flip-flops (main characteristics). Building different types of flip-flops based on basic microchips.	1-13
3	L LW IW	1 2 3	**Topic 3. Registers** Purpose and classification of registers. Parallel and serial registers. Features of circuit implementation and functioning of different types of registers. Building circuits using registers.	1-13
4	L PW LW IW	1 2 2 3	**Topic 4. Counters.** Purpose, classification and main characteristics of binary counters. Adding and subtracting binary counters. Reversible counters. Features of circuit implementation and operation. Counters with an arbitrary counting module: methods of construction, features of circuit implementation and functioning. Building circuits using counters.	1-13
			Content module 2	
5	L PW IW	2 2 3	**Topic 5. Multiplexers and demultiplexers.** Purpose, principles of construction and operation of multiplexers and demultiplexers. Construction of circuits using multiplexers and demultiplexers.	1-13
6	L LW IW	2 2 3	**Topic 6. Decoders and Encoders.** Basic principles of decoders construction. Purpose, classification and main characteristics. Construction of multi-bit decoders. Construction of circuits using decoders. Operation of the decoder in the demultiplexer mode. Purpose, classification, main characteristics and principles of construction of encoders.	1-13
7	L PW IW	1 2 3	**Topic 7. Adders.** Purpose and classification of adders. Principles of construction of half adders and full single-bit adders. Construction of multi-bit adders. Examples of circuits using adders.	1-13
8	L IW	1 3	**Topic 8. Control schemes and code comparison.** Basic principles of designing control circuits for data transmission. Purpose and principles of construction of digital comparators. Construction of multi-bit code comparison schemes.	1-13

1	2	3	4	5
9	L LW IW	1 4 3	**Topic 9. Pulse devices based on digital integrated circuits.** Pulse shaping devices. Generators of pulse signals. Organization of pulse signal delay.	1-13
10	L IW	1 3	**Topic 10. Converters of information.** Signal converters. Basic principles of ADC construction (features of circuit implementation). Basic principles of DAC construction (features of circuit implementation).	1-13
11	L IW	1 6	**Topic 11. Memory devices.** Purpose, main characteristics and classification of memory devices. Features of the circuitry of memory elements. Random Access Memory and Read-Only Memory devices. Reprogrammable memory devices.	1-13
12	L PW IW	2 4 6	**Topic 12. Programmable logic devices.** Purpose, application and structure of a programmable logic devices (PLD). Classification of PLD. Architectural features and purpose of different types of PLD. Basic parameters of PLD. Programming languages for logic devices. Computer-aided design systems. Interface of the Quartus II design environment. Directions and prospects for PLD development. **Conclusion.** Trends in the further development of computer circuitry.	1-13
Total (hours)		90		

8. Methods of learning and teaching

At lecture the material is taught orally, with the main points of the lecture recorded in a notebook. A media projector and a computer are used to demonstrate presentations.

During practical works, students prepare for laboratory work: they develop and analyze variants of the schemes of the necessary devices.

In laboratory works, students perform and demonstrate individual tasks. To do this, they use the necessary software and hardware tools: personal computers, electronic circuit modeling programs, universal mounting boards and sets of necessary components (elements) of electronic circuits, measuring instruments (including virtual ones).

During their independent work, students develop and correct circuits according to

their individual tasks, as well as debug and model them using electronic circuit modeling programs.

Students have the opportunity to learn and develop real projects by participating in the Innovation Campus program of NTU "KhPI". Students receive additional knowledge through non-formal education, thanks to organizations that provide educational services, such as NixSolution, GlobalLogis, EPAM, etc.

9. Methods of control

Current control is realized in the form of questioning during auditory lessons, defense of reports on laboratory work, speeches at practical works, and tests.

The control of the component of the educational program, which is mastered during the student's independent work, is carried out by checking the lecture material by checking the test papers, and in laboratory and practical works by checking the completed tasks.

Semester control is organized in the form of an exam within the terms established by the curriculum. Semester control is conducted in oral and written forms on the basis of examination tickets, which include examination questions and control tasks (tasks).

The results of the current control (current academic performance) may be taken into account as auxiliary information for assigning a grade in this discipline.

The student is considered admitted to the semester exam in the discipline, provided that all practical and laboratory works provided by the curriculum in the discipline are fully completed**.**

The knowledge and competencies that students will receive at external courses of companies (GlobalLogic, EPAM, etc.) and through participation in the Innovation Campus program of NTU "KhPI" may be partially credited in the form of points for practical (laboratory) work.

10. Distribution of points received by students and the scale of grading of knowledge and skills

According to the main provisions of the ECTS, the grading system should be

understood as a set of methods (written, oral and practical tests, exams, projects, etc.) used to assess the achievements of students.

Successful grading of learning outcomes is a prerequisite for awarding credits to a student. Therefore, statements about the learning outcomes of program components should always be accompanied by clear and appropriate grading criteria for awarding credits.

This makes it possible to state whether the student has acquired the necessary knowledge, understanding, and competencies.

Table 2 – Distribution of points for assessing student performance for the exam

Practical works	Laboratory works	Tests	Exam	Total
30	30	20	20	100

Grading criteria are descriptions of what the student should do to demonstrate that the learning outcome has been achieved.

The main conceptual provisions of the grading system for students' knowledge and skills are:

1. Improving the quality of training and competitiveness of specialists by stimulating independent and systematic work of students during the academic semester.
2. Establishing constant feedback from teachers to each student and timely adjusting their learning activities.
3. Increasing the objectivity of student knowledge grading is achieved by monitoring during the semester using a 100-point scale (Table 3).

Grades are necessarily converted to the:

– national scale (with the state semester grade of "excellent", "good", "satisfactory" or "unsatisfactory");

– ECTS scale (A, B, C, D, E, FX, F).

Table 3 – Scale of grading of knowledge and skills (national and ECTS)

Rating grade, points	ECTS grade and its definition	National grade	Grade criteria	
			positive	negative
1	2	3	4	5
90-100	A	Excellent	-deep knowledge of the educational material contained in the main and additional literature sources; - ability to analyze the phenomena under study in their interconnection and development; - ability to make theoretical calculations; - answers to questions are clear, laconic, logically consistent; - ability to solve complex practical tasks	- answers to questions may contain minor inaccuracies
82-89	B	Good	- deep level of knowledge in the scope of the mandatory material provided by the module; - ability to give reasoned answers to questions and perform theoretical calculations; - ability to solve complex practical tasks	- the answers to the questions contain certain inaccuracies
75-81	C	Good	- strong knowledge of the studied material and its practical application; - ability to give reasoned answers to questions and perform theoretical calculations; - ability to solve practical tasks	- inability to use theoretical knowledge to solve complex practical tasks

1	2	3	4	5
64-74	D	Satis-factory	- knowledge of the basic fundamental provisions of the studied material and their practical application; - ability to solve simple practical tasks	- inability to give reasoned answers to questions; - inability to analyze the material presented and perform calculations; - inability to solve complex practical tasks
60-63	E	Satis-factory	- knowledge of the basic fundamental provisions of the module material; - ability to solve the simplest practical tasks	- unawareness of certain (non-principled) issues from the module material; - inability to express opinions consistently and reasonably; - inability to apply theoretical provisions in solving practical tasks
35-59	FX (additional study is required)	Unsatis-factory	- additional study of the module material can be completed within the time frame provided by the curriculum	- unawareness of the basic fundamental provisions of the module's educational material; - significant errors in answering questions; - inability to solve simple practical tasks
1-34	F (re-study is required)	Unsatis-factory		- complete lack of knowledge of a significant part of the module's educational material; - significant errors in answering questions; - unawareness of the main fundamental provisions; - inability to navigate simple practical tasks

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Educational edition

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