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

Computer Systems Software Department

Theory of information and coding

Syllabus

Course Requisites

Cycle of Higher Education	*First cycle of higher education (Bachelor's degree)*
Field of Study	*12 Information Technologies*
Speciality	*121 Software engineering*
Educational program	*Software Engineering of Multimedia and Information Retrieval Systems*
Discipline status	*Elective*
Study form	*Full-time*
Year of study, semester	*3 year, 5 semester*
ECTS workload	*Lectures - 36 hours, practical classes - 18 hours, independent work - 66 hours.*
Testing and assessment	*Final test*
Course Schedule	*Classes by the timetable http://rozklad.kpi.ua/*
Language	*English*
Course Instructors	Lecturer: PhD, Associate Professor, Vasyl Yurchyshyn, *vasylPZKS@gmail.com* Teacher of computer workshop: *PhD, Associate Professor, Vasyl Yurchyshyn,vasylPZKS@gmail.com*
Access to the course	Google classroom, http://fpm.kpi.ua/archive

Outline of the Course

1. Course description, goals, objectives, and learning outcomes

The study of the discipline "Theory of information and coding" allows students to develop the competencies necessary for solving practical problems related to the development and use of modern computer systems in the everyday professional activities of a programmer.

The purpose of studying the discipline "Theory of information and coding" is the formation in students of the ability to independently develop software for the design of modern computer systems and their use, as well as to use third-party software to create modern high-performance computer systems.

The subject of the discipline "Theory of information and coding" is: basic concepts of information theory; message source model; models of data transmission channels; coding as a form of information presentation; optimal coding, as a form of information presentation for the purpose of data compression; redundant (jamming-resistant) coding, as a form of presenting information for the purpose of detection, or detection and correction of errors in messages.

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The study of the discipline "Theory of information and coding" contributes to the formation of students of professional competences (PC) necessary for solving practical tasks of professional activities related to the development,
improvement and operation of information system software:

Competencies, the formation of which is facilitated by this discipline:

PC 01	*Ability to identify, classify and formulate software requirements.*
PC 02	*Ability to participate in software design, including its structure, behavior and functioning processes modeling (formal description).*
PC 03	*Ability to develop software systems architectures, modules and components.*
PC 05	*Ability to follow specifications, standards, rules and recommendations in the professional field during the life cycle processes implementation*
PC 06	*Ability to analyze, select and apply methods and tools to ensure information security (including cybersecurity).*
PC 07	*Knowledge of information data models, the ability to create software for data storage, retrieval and processing.*
PC 13	*Ability to reasonably select and master software development and maintenance tools.*
PC 14	*Ability to algorithmic and logical thinking.*
PC 16	*Ability to develop algorithms for implementing statistical data analysis methods.*
PC 20	*Ability to apply the acquired fundamental mathematical knowledge to develop calculation methods in the multimedia and information retrieval systems creation.*

The formation of the specified competencies contributes to the formation of the following program learning outcomes (PLO) in students according to the educational program:

PLO 01	*To analyze, purposefully search and select the necessary information and reference resources and knowledge to solve professional problems, taking into account modern advances in science and technology.*
PLO 05	*To know and apply relevant mathematical concepts, domain methods, system and object-oriented analysis and mathematical modeling for software development.*
PLO 06	*Ability to select and use the appropriate task of software development methodology.*
PLO 07	*To know and to apply in practice the fundamental concepts, paradigms and basic principles of the functioning of language, instrumental and computational tools of software engineering.*
PLO 09	*To be able to use collecting, formulating and analyzing software requirements methods and tools.*
PLO 12	*To apply effective approaches to software design in practice.*
PLO 13	*To know and apply methods of developing algorithms, designing software and data and knowledge structures.*
PLO 18	*To know and be able to apply information technology of processing, storage and transmission of data.*
PLO 21	*To know the tools, analyze, select, skillfully apply the information security (including cybersecurity) and data integrity means in accordance with the applied tasks and software systems.*

PLO 43	*To know and be able to use in practice the existing software resources and libraries for processing of textual information and multimedia data in information retrieval systems.*

2. Discipline prerequisites and postrequisites (place in the structural and logical education scheme according to the relevant educational program)

The successful study of the discipline "Theory of information and coding" is preceded by the study of the disciplines

"Mathematical Analysis", "Computer Discrete Mathematics", "Linear Algebra and Analytical Geometry", "Theory of Probability" of the curriculum of bachelor's training in the specialty 121 Software Engineering.

The theoretical knowledge and practical skills obtained during the mastering of the discipline "Theory of Information and Coding" ensure the justified implementation and selection of coding methods and algorithms in Information Systems and Technologies and the successful completion of course projects and diploma projects in the specialty 121 Software Engineering.

3. Content of the academic discipline

The discipline "Theory of information and coding" involves the study of the following topics:
Topic 1 Introduction to information theory. Signals. Topic 2. Quantitative assessment of information.
Topic 3 Effective coding. Topic 4. Interference-resistant coding.
Modular test.
Final test.

4. Coursebooks and teaching resources

Basic references:

1. Zhurakivsky Yu.P., Poltorak V.P. Theory of information and coding. Kharkiv. 2011
2. Soroka L.S., Zhuchenko O.S. and other. Basics of information theory and coding. Kharkiv. 2008.
3 Cymbal V.P. Theory of information and coding. Kyiv: Higher School, 1992.
4 Cymbal V.P. Task on the theory of information and coding. Kyiv: Higher School, 1986.
5 R. Hamming Coding theory and information theory: Textbook - K., 1983.

Educational content

5 Methods of mastering the discipline (educational component)

№	*Training session type*	*Lesson description*
TOPIC 1. Introduction to information theory. Signals.		

1	*Lecture 1* *Postulates of the applied theory of information.* *Concept of information..*	*Information theory as an integral part of cybernetics. Concept, types and structure of information systems. Basic concepts and definitions of information, message, signal. Types and forms of information, presentation of information. Structure of information.* *Self-study task: to process the lecture material. Item 6, No. 1.*
2	*Practical lesson 1* *Numerical systems.*	*Numerical systems. Presentation and transfer of numerical information from one system to another* *Tasks for independent work: complete examples of presentation and translation, write down options for correct solutions in the synopsis. p. 6, No. 1, 2.*
3	*Lecture 2.* *Signals in the information processing and transmission system*	*Signals in the information processing and transmission system. Time and frequency forms of signal presentation* *Tasks for independent work:* *repeat the material of the lecture, item 6, number 3.*
4	*Lecture 3 Fourier transform*	*Direct and reverse. Fourier transform. Self-study task: to work out* *Lecture material,6,No.4.*
5	*Practical lesson 2* *Fourier transform.*	*Direct and inverse Fourier transform. Task for independent work: work out examples of direct and inverse conversion, write in* *summary of solution options. p. 6, No. 4, 5.*
6	*Lecture 4* *Discretization and quantization*	*Discretization. Quantization by level and by time. Kotelnikov's theorem.* *Task for S-S: to work out the lecture material 6, No. 6.*
TOPIC 2. Quantitative assessment of information		
7	*Lecture 5* *The concept of information evaluation*	*Amount of information and degree of uncertainty. Evaluation of syntactic and semantic information. Structural measure of information (geometric, combinatorial, additive). Statistical measure of information. Semantic measure of information (content, expediency, essentiality).* *Task for S-S: to process the lecture material Item 6, No. 7.*
8	*Practical session 3* *Quantitative assessment information*	*Calculation of the amount of information in messages for different input values. entropy of the message source. Analyze the results.*

9	*Lecture 6* *The concept of entropy. Conditional and mutual entropy.* *Redundancy of information*	*Entropy of discrete messages and its properties. Entropy of continuous messages. Entropy of complex discrete and continuous messages. Entropy and amount of information with statistical dependence of message elements. Conditional entropy. Mutual entropy. Information overload of messages.* *Task for independent work: to work out the lecture material item 6, number 9.*
10	*Practical lesson 4.* *Entropy (unconditional and conditional).*	*Calculation of the entropy of the message source for different values of the input data, to investigate the conditions for reaching the extremum of the entropy of the message source. Analyze the results, formulate conclusions. No. 6, No. 9, 10.*
Modular control work		
TOPIC 3. Effective coding		
11	*Lecture 7* *The concept of efficient coding*	*The concept of coding. Types of coding. The concept of efficient coding. Types of codes. Code tree. Shannon's theorem for an interference-free channel. Task for S-S: to work out the lecture material item 6, number 11.*
12	*Practical lesson 5.* *Efficient coding*	*Effective coding. Types of codes. Code tree. Analyze the results, formulate conclusions. Item 6, No. 11, 12.*
13	Lecture 8 Prefix codes	*Concept of prefix code. Kraft's inequality* *Task for S-S: to work out the lecture material. Item 6, No. 13.*
14	*Lecture 9* *Fano code and Shannon code*	*Fano code construction algorithm. Shannon's code construction algorithm.* *Task for S-S: to work out the lecture material No. 6, No. 14.*
15	*Lecture 10* *Huffman code.*	*A simple and adaptive Huffman code construction and decoding algorithm. Huffman tree.* *Task for S-S: to work out the lecture material. Item 6, No. 15.*
16	*Practical lesson 6. Codes of Fano, Shannon, Huffman.*	*Based on the received input data, encode the symbols of the primary source of messages with the symbols of the secondary source of messages, according to the Shannon-Fano and Huffman code algorithms, prove the optimality of the code by calculations. Analyze the results, formulate conclusions. item 6, №14-16*
Topic 4. Interference-resistant coding.		

17	*Lecture 11* *Immunity of coding.* *Basic concepts.*	*The concept of interference-resistant coding. Shannon's theorem for a channel with interference. Linear codes. Systematic and non-systematic codes. The weight of words. Code distance. Allowed and forbidden combinations. Geometrical interpretation of the relationship between the code distance and the correcting ability of the code.* *Task for S-S: to process the lecture material. Item 6, No. 17.*
18	*Lecture12* *Methods interference-resistant coding.*	*Code with check for oddness. Inverse code.* *Iterative code.* *Task for S-S: to process the lecture material. Item 6, No. 18.*
19	*Practical lesson 7.* *Codes that detect errors.*	*Based on the received input data, encode the incoming message with the specified codes, introduce distortion of the permissible multiplicity into the code, decode the distorted code, demonstrate on various examples whether it performs the given function or not (detection of errors), determine the characteristics of the code, analyze the results,* *formulate conclusions. No. 6, No. 18, 19.*
20	*Lecture 13* *Linear group codes*	*The actual capabilities of linear group codes for error detection. Generating matrix. Verification matrix - its structure and connection with the generating matrix. Syndromes.* *Task for S-S: to work out the lecture material item 6, number 20.*
21	*Lecture 14* *Hamming codes.*	*Systematic and non-systematic Hamming codes, coding and decoding algorithms.* *Task for S-S: to work out the lecture material item 6, number 21.*
22	*Practice 8. Codes that correct errors.*	*Based on the received input data, encode the incoming message with a Hamming code, introduce distortion of the permissible multiplicity into the code, decode the distorted code, demonstrate on various examples whether it performs or does not perform the given function, determine the characteristics of the code, analyze the results, formulate conclusions.* *Task for S-S: to work out the lecture* *material. No. 6, No. 18, 21.*
23	*Lecture 15* *Construction of cyclic codes*	*Minimal polynomials. Polynomials that* *give birth to Systematic and non-systematic cyclic codes. Generating and verification matrices for cyclic codes.* *Task for S-S: to work out the lecture material item 6, number 23.*

24	*Lecture 16* *Correction of errors* *in cyclic codes*	*Specific coding algorithms and* *decoding for cyclic codes. Bowes-Choudhury-Hockingham codes. Item 6, No. 24.*
25	*Practical lesson 9. Linear and cyclic codes.*	*Based on the received input data, encode the incoming message with a cyclic code, introduce distortions of permissible multiplicity into the code, decode the distorted code, demonstrate on various examples whether it performs or does not perform the given function, determine the characteristics of the code, analyze the results, formulate conclusions. Task for S-S: to work out the lecture* *material. p. 6, No. 23, 24, p. 6, No. 25.*
26	*Lecture 17* *Reed-Solomon codes*	*Correction of errors in data blocks. Reid-Solomon codes* *Task for S-S: to work out the lecture* *material No. 6, No. 17.*
27	*Lecture 18* *Data compression*	*Data compression during transmission and during archiving* *Task for S-S: to work out the lecture material item 6, number 18.*
Modular test		

6 Self-study

The discipline "Theory of information and coding" is based on independent preparations for classroom classes on theoretical and practical topics.

№	*The name of the topic that is submitted for independent study*	*Hours of study*	*References*
1	*Preparing for lecture 1*	*1*	*1, cmop. 8-20.*
2	*Preparing for practical class 1*	*2*	*1, cmop. 76-82*
3	*Preparing for lecture 2*	*1*	*1, cmop. 53-63.*
4	*Preparing for lecture 3*	*1*	*2, cmop. 21-58.*
5	*Preparing for practical class 2*	*2*	*2, cmop. 54-81*
6	*Preparing for lecture 4*	*2*	*1, cmop. 60-65.*
7	*Preparing for lecture 5*	*2*	*1, cmop. 21-27.*
8	*Preparing for practical class 3*	*2*	*1, cmop. 21-27*
9	*Preparing for lecture 6*	*1*	*1, cmop. 28-48.*
10	*Preparing for practical class 4*	*2*	*1, cmop. 28-48*

11	Preparing for modular test	4	1; 2; 3; 4; 5.
12	Preparing for lecture 7	2	1, cmop. 72-110.
13	Preparing for practical class 5	2	1, cmop. 72-110
14	Preparing for lecture 8	1	1, cmop. 84-85.
15	Preparing for lecture 9	2	1 c. 99-111.
16	Preparing for lecture 10	2	1 cmop. 102-111.
17	Preparing for practical class 6	3	1, c. 99-111
18	Preparing for lecture 11	2	1 cmop. 158-163.
19	Preparing for lecture 12	2	1, cmop. 134-138.
20	Preparing for practical class 7	2	1, cmop. 134-138
21	Preparing for lecture 13	1	1, cmop. 158-165).
22	Preparing for lecture 14	2	1, cmop. 166-170.
23	Preparing for practical class 8	2	1, cmop. 166-170
24	Preparing for lecture 15	2	1 cmop. 171-180.
25	Preparing for lecture 16	2	1, cmop. 180-185.
26	Preparing for practical class 9	2	1, cmop. 158-185
27	Preparing for lecture 17	3	1 cmop. 198-200.
28	Preparing for lecture 18	2	1 cmop. 221-238.
29	Preparing for modular test	4	1; 2; 3; 4; 5.
30	Preparing for final test	8	1; 2; 3; 4; 5.

Policy and Assessment

7. Course policy

- *Attending lectures and practical classes is mandatory.*
- *Rules of behavior in classes: activity, respect for those present, turning off phones.*
- *Adherence to the policy of academic integrity.*
- *Rules for the protection of practical work: work must be done according to the option of the student, which is determined by his number in the group list.*
- *The rules for assigning incentive and penalty points are as follows. Incentive points are awarded for:*

- accurate and complete answers in surveys based on lecture materials (maximum number of points for a blitz survey - 3 points).

- a creative approach in performing practical work (the maximum number of points for work is 2 points). Penalty points are calculated for:

- plagiarism (inconsistency of the task variant, identity of implementation among different works):

-5 points for each attempt.

8. Monitoring and grading policy

During the semester, students perform 9 practical works. The maximum number of points for each of the practical works: 6 points.

Points are awarded for:

- quality of practical work: 0-3 points;

- answer during the defense of practical work: 0-3 points; Performance evaluation criteria:

3 points – the work is done qualitatively, in full;

2 points - the work is completed in full, but contains errors; 0 points – work not completed.

Answer evaluation criteria:

3 points – the answer is complete, reasoned with answers to clarifying questions;

2 points – there are errors in the answer;

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

The maximum number of points for the performance and defense of practical works: 6 points × 9 practical works = 54 points.

During the semester, blitz polls on the topics of past lectures take place at the lectures. Maximum points for all blitz polls: 2 points. The number of blitz surveys per student is unlimited.

During the semester, lectures take place on the topic of the current lesson. Maximum points for all surveys: 3 points. The number of surveys on the topic of the current lesson for one student is unlimited.

During the semester, students perform a modular test, which consists of two parts: information theory and coding theory.

The task for each part of the modular test consists of 3 questions - 2 theoretical and 1 practical. The answer to each theoretical question is worth 8 points, and the answer to a practical question is worth 7 points.

Evaluation criteria for each theoretical question of the test:

8 points – the answer is correct, complete, well-argued;

7 points – the answer is correct, detailed, but not very well argued;

5-6 points - in general, the answer is correct, but has flaws;

3-4 points – there are minor errors in the answer;

1-2 points – there are significant errors in the answer;

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

Evaluation criteria for the practical test question:

7-6 points – the answer is correct, the calculations are completed in full;

5-4 points – the answer is correct, but not very well supported by calculations;

3 points - in general, the answer is correct, but has flaws;

2 points – there are errors in the answer;

1 points – there are significant errors in the answer;

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

The maximum number of points for a modular control work:

8 points × 2 theoretical questions + 7 points = 23 points. For two parts of the MKR - 46 points. The rating scale for the discipline is equal to:

R = RS = 54 points + 46 points = 100 points.

Calendar control: is conducted twice a semester as a monitoring of the current state of fulfillment of the syllabus requirements.

At the first certification (8th week), the student receives "credited" if his current rating is at least 15 points (50% of the maximum number of points a student can receive before the first certification).

At the second certification (14th week), the student receives "passed" if his current rating is at least 20 points (50% of the maximum number of points a student can receive before the second certification).

Semester control: assessment

Conditions for admission to semester control:

With a semester rating (RC) of at least 60 points and the enrollment of all practical work, the student receives credit "automatically" according to the table (Table of correspondence of rating points to grades on the university scale). Otherwise, he has to perform the final control work.

A necessary condition for admission to the credit control work is the performance and protection of practical works.

If the student does not agree with the "automatic" grade, he can try to improve his grade by writing a credit test, while his points received for the semester are kept, and the better of the two grades received by the student is assigned ("soft" grading system) .

The final performance score or the results of Final test the Fail/ Pass are adopted by university grading system as follows:

Points	*Grade*
100-95	Excellent
94-85	Very good
84-75	Good
74-65	Satisfactorily
64-60	Enough
< 60	Unsatisfactorily
Admission conditions are not met	Not admitted

Course syllabus:

Is created by PhD, Associate Professor Vasyl Yurchyshyn

Approved by Computer Systems Software Department (protocol № 8, 22.01.2025)

Approved by the Applied Mathematics Faculty Methodology Commission (protocol № 8, 03.02.2025)