Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of Computing Engineering

Basics of computer systems and networks

Syllabus

Requisites of the Course

Cycle of Higher Education	**First cycle of higher education (Bachelor's degree)**
Field of Study	12 Information Technologies
Specialty	121 Software engineering
Education Program	Computer Systems Software Engineering
Type of Course	Normative
Mode of Studies	full-time
Year of studies, semester	First year, second semester
ECTS workload	5 credits (ECTS). Time allotment - 150 hours, including 72 hours of classroom work, and 78 hours of self-study.
Testing and assessment	Exam
Course Schedule	2 classes per week by the timetable https://schedule.kpi.ua
Language of Instruction	English
Course Instructors	Lecturer and lab teacher: PhD, Associate Professor, Oleksandr Rokovyi, email: rokovyi@comsys.kpi.ua
Access to the course	https://cloud.comsys.kpi.ua/s/X2KwzHiHKeSjBkQ

Outline of the Course

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

Modern information technologies are closely related to computer networks. The efficiency of many elements of various computer systems depends on the quality of computer networks. The development of high-quality software is impossible without taking into account the characteristics of data transmission in computer networks. The correct choice of technologies, protocols and services will ensure reliable and safe functioning of computer systems. The course "Basics of computer systems and networks" in addition to theoretical issues of architecture and principles of building computer networks also pays a lot of attention to practical aspects of their use. That is why this course can be useful for future information technology specialists.

The purpose of this course is to train specialists who have knowledge of the architecture and principles of operating computer networks based on the TCP/IP protocol suite, as well as practical skills in using network technologies to solve various tasks.

The subject of the course is the theoretical and practical foundations of data transmission in computer networks, which ensure the necessary level of speed, reliability and security.

The course "Basics of computer systems and networks" provides the following program competencies and program results of the educational and professional program: FK06, FK08, FK15, PRN01, PRN18, PRN21, PRN26:

- the ability to analyze, choose and apply methods and tools to ensure information security (including cyber security);

- the ability to apply fundamental and interdisciplinary knowledge to successfully solve software engineering tasks;

- the ability to develop and use network technologies;

- to analyze, purposefully search for and select information and reference resources and knowledge necessary for solving professional tasks, taking into account modern achievements of science and technology;

- to know and be able to apply information technologies for data processing, storage and transmission;

- to know, analyze, choose, competently apply the means of ensuring information security (including cyber security) and data integrity in accordance with the applied tasks being solved and the software systems being created;

- to know the principles of building and functioning of high-performance computer systems.

According to the program of the course, after learning this course, students must demonstrate the following educational results.

Knowledge:

- purpose and functions of the open system interconnection reference model levels;

- the main protocols of the TCP/IP protocol suite and their functions;

- standards and specifications of data transmission technologies and network equipment;

- mechanisms of reliable and secure data transmission in computer networks;

- basic topologies of computer networks;

- encoding methods and features of data transmission in various media types;

- algorithms and main protocols of packet routing in computer networks;

- socket API.

Skills:

- configure parameters of network interfaces;

- configure the basic parameters of the main network services;

- perform calculations of network parameters;

- choose equipment when designing computer networks;

- locate and correct errors in computer networks;

- provide the necessary level of security during data transmission in computer networks;

- develop software that uses low-level data transmission functions in a computer network.

Experience:

- working with network traffic analyzers and generators;

- development of network software.

2. Prerequisites and post-requisites of the course (the place of the course in the scheme of studies in accordance with curriculum)

In order to successfully master the course "Basics of computer systems and networks" in accordance with the educational program, it is necessary to master the knowledge of the courses: "Computer discrete mathematics", "History of science and technology".

Competences, knowledge and skills acquired in the study of the course "Basics of computer systems and networks" can be used to study the courses: "Linux workshop", "System programming", "Networks and network information technologies".

3. Content of the course

Chapter 1. Architecture of computer networks.

Topic 1.1. Problems of building networks. Protocol. Interface.

Topic 1.2. Open systems interaction reference model (ISO/OSI).

Topic 1.3. TCP/IP protocol suite.

Chapter 2. Network interface layer of the TCP/IP protocol suite.

Topic 2.1. Types of medium and their characteristics.

Topic 2.2. Media Access Control types.

Topic 2.3. Architecture of switches. Switching table.

Topic 2.4. IEEE802 standards group.

Chapter 3. The network layer of the TCP/IP protocol suite.

Topic 3.1. IP protocol.

Topic 3.2. IP addressing.

Topic 3.3. Auxiliary protocols of the network layer.

Topic 3.4. DHCP protocol.

Topic 3.5. Routing algorithms.

Topic 3.6. Routing protocols.

Chapter 4. The transport layer of the TCP/IP protocol suite.

Topic 4.1. UDP protocol.

Topic 4.2. TCP protocol.

Topic 4.3. Flow control in TCP.

Topic 4.4. Network address translation.

Section 5. Network security.

Topic 5.1. Traffic filtering in computer networks.

Topic 5.2. Virtual private networks - VPN.

Chapter 6. The application layer of the TCP/IP protocol suite.

Topic 6.1. The basic protocols of the application layer of the TCP/IP suite.

Topic 6.2. Sockets programming.

4. Coursebooks and teaching resources

Main literature.

1. Larry Peterson, Bruce Davie. Computer Networks: A Systems Approach, 2019. – 489 p. URL: https://github.com/SystemsApproach/book/releases/download/v6.1/book.pdf

2. James Kurose, Keith Ross. Computer Networking: A Top-Down Approach, Global Edition, 8th Edition. Pearson Education, 2021.

3. Andrew S. Tanenbaum, Nick Feamster, David J. Wetherall. Computer Networks, 6th edition, 2021. – 946 p.

Supplementary literature.

1. Peter L Dordal. An Introduction to Computer Networks, 2022. – 963 p. URL: http://intronetworks.cs.luc.edu/current/ComputerNetworks.pdf

2. Olivier Bonaventure. Computer Networking: Principles, Protocols and Practice, Release 2021. – 413 p. URL: https://www.computer-networking.info/_downloads/CNP3-2021.pdf

3. Paul Cobbaut. Linux Networking, 2015. – 294 p. URL: https://linux-training.be/linuxnet.pdf

4. Linux Administration II Linux as a Network Client. Version 4, 2015 – 217 p. URL: https://www.tuxcademy.org/download/en/adm2/adm2-en-manual.pdf

Educational content

5. Methodology

5.1. Lectures.

№	Lecture topic and list of main issues	Number of hours
1	**Open systems interaction reference model (ISO/OSI).** Course structure. Problems of building networks. Protocol. Interface. Encapsulation. OSI model layers. Functions of OSI model layers. Protocol data unit. TCP/IP protocol suite. Comparison of OSI and TCP/IP. **Self-study**: familiarize yourself with alternative TCP/IP suite implementations of the open systems interaction reference model.	2
2	**The network layer of the TCP/IP suite. IP protocol.** The place of the IP protocol in the OSI and TCP/IP models. IP protocol services. IP packet format for protocol versions 4 and 6. Routing. Fragmentation of packets. **Self-study**: familiarize yourself with implementations of quality of service (QoS) mechanisms in the IP protocol.	2
3	**IP addressing.** Global and local addresses. IP address structure. Classes of IP addresses. Classless routing (Classless Inter-Domain Routing, CIDR). Subnet mask. Special purpose IP addresses. Network partitioning into subnets. **Self-study**: familiarize yourself with the interaction of the network and data link layers during packet transmission.	2
4	**Auxiliary protocols of the network layer.** ICMP protocol. ICMP header format. Types of ICMP messages. Ping and traceroute utilities. ARP protocol. ARP message format. ARP table. **Self-study**: familiarize yourself with the NDP protocol for IPv6.	2
5	**DHCP protocol.** Ways to configure parameters of network interfaces. DHCP message. DHCP configuration information. Scheme of DHCP protocol operation. DHCP relay. IP address lease time parameters. **Self-study**: familiarize yourself with DHCP for IPv6.	2
6	**Routing algorithms.** Classification of routing algorithms. Routing table structure. Static routing. Distance-vector routing algorithms. Link state routing algorithms.	2

№	Lecture topic and list of main issues	Number of hours
	Self-study: familiarize yourself with multicast and broadcast routing algorithms.	
7	**Routing protocols.** RIP protocol. Filling routing tables in RIP. Methods for resolving incorrect routes in RIP. OSPF protocol. Stages of filling routing tables in OSPF. **Self-study**: familiarize yourself with the BGP protocol.	2
8	**Physical level of the OSI model.** Media types and their characteristics. Physical topology. Modulation. Coding. Synchronization. **Self-study**: familiarize yourself with structured cabling.	2
9	**Data link layer of the OSI model.** Media access control. Data link frame. Detection and correction of errors during data transmission at data link layer. Architecture of switches. Switching table. Limitation of switches. **Self-study**: familiarize yourself with the STP protocol.	2
10	**Ethernet technology. Wireless networks**. IEEE802 standards group. Evolution of IEEE802.3 standards. Media access control in Ethernet. Collision occurrence. Ethernet frame format. Wireless local networks of IEEE802.11 standards. **Self-study**: familiarize yourself with IEEE802.15 (Bluetooth) standards.	2
11	**The transport layer of the TCP/IP suite. UDP protocol.** Purpose of the transport layer. Reliability of data transmission. Types of ports. View connections and ports. Transport protocols of the TCP/IP suite. Purpose of the UDP protocol. UDP header format. Network services that use UDP. **Self-study**: familiarize yourself with the SCTP, DCCP protocols.	2
12	**TCP protocol.** Purpose of the TCP protocol. TCP header format. Connection establishment and termination in TCP. **Self-study**: familiarize yourself with congestion control mechanisms: cubic, vegas, veno.	2
13	**TCP protocol.** TCP sliding window. Flow control in TCP. Congestion control in TCP. **Self-study**: familiarize yourself with congestion control mechanisms: westwood, illinois, hybla, reno.	2
14	**Broadcasting of network addresses.** Reasons to use NAT. Static NAT. Dynamic NAT. NAT overloaded. NAPT work scheme. Advantages and disadvantages of using NAT. **Self-study**: familiarize yourself with NAT traversal mechanism.	2
15	**Traffic filtering in computer networks.** Types of firewalls. Filtering rules. Stateful network filter. Application layer firewall. **Self-study**: familiarize yourself with intrusion detection systems - IDS.	2

№	Lecture topic and list of main issues	Number of hours
16	**Virtual private networks - VPN.** Basics of virtual private networks. Types of virtual private networks. VPN services. Ways of creating protected tunnels. Layers of VPN implementation. Protocols: IPSec, PPTP, L2F, L2TF. **Self-study**: familiarize yourself with IKE protocol.	2
17	**The application layer of the TCP/IP suite.** Basic protocols of the application layer in TCP/IP suite. Client-server architecture. Peer-to-peer architecture. DNS Name System. Web services. Email services. Instant messaging services. Multimedia data transmission services. **Self-study**: familiarize yourself with file transfer services.	2
18	**Sockets programming.** Berkeley sockets. The main functions of sockets. Types of sockets. Blocking and non-blocking sockets. Features of the client and server parts of sockets. Debugging sockets. **Self-study**: familiarize yourself with secure version of sockets based on SSL/TLS.	2
	Total:	36

5.2. Laboratory classes (computer workshop).

The main task of laboratory classes (computer workshop) is to provide students with the necessary practical skills for working with the TCP/IP protocol suite.

To perform laboratory work, each student must install Cisco Packet Tracer (https://www.netacad.com/courses/packet-tracer) or GNS3 (https://gns3.com/software/download) software at their workplace.

№	Topic of laboratory work (computer workshop)	Number of hours
1	**TCP/IP protocol suite diagnostic utilities.** Study diagnostic tools for TCP/IP protocol suite: ping, traceroute, nslookup. Familiarize with Packet Tracer/GNS3 computer network simulation software.	4
2	**Configuration of network interfaces using the DHCP protocol.** Configuring a DHCP server using Packet Tracer/GNS3 computer network simulation software.	4
3	**Static routing. Subnetting.** Dividing the source network into subnets for a given number of nodes in each. Configuring static routing for calculated subnets using computer network simulation software Packet Tracer/GNS3.	4
4	**Dynamic routing.** Configuration of RIP and OSPF dynamic routing protocols using computer network simulation software Packet Tracer/GNS3.	4
5	**IPv6 protocol.**	4

№	Topic of laboratory work (computer workshop)	Number of hours
	Configuring parameters and checking the functionality of the IPv6 protocol using computer network simulation software Packet Tracer/GNS3.	
6	**Wireless networks.** Configuring wireless network equipment using Packet Tracer/GNS3 computer network simulation software.	4
7	**Network Address Translation (NAT). Network traffic filtering.** NAT server and packet filter setup using Packet Tracer/GNS3 computer network simulation software.	4
8	**Wireshark network traffic analyzer.** Introduction to Wireshark network traffic capture and analysis software.	4
9	**Client and server part of the custom protocol.** Development of client and server parts that implement the functionality of the custom protocol.	4
	Total:	18

6. Self-study

6.1. Topics that are submitted for self-study.

№	Topic submitted for self-study	Number of hours
1	Scapy network traffic generator.	2
2	Quality of service in computer networks.	2
3	SNMP network management protocol.	2
	Total:	6

Before each class, the student performs self-study training in accordance with the topic of the lecture or laboratory work for at least two hours.

Thus, the student's self-study work during the semester should be: 36 + 36 + 6 = 78 hours.

Policy and Assessment

7. Course policy

Course policy:

- for successful study of the course it is desirable to be present at all lectures;
- in lectures it is allowed to use any technique only for the purpose related to the lesson, without disturbing other students and teachers;
- during the lecture you can ask questions to the teacher, for this you need to raise your hand and get permission;
- it is forbidden to speak at lectures without the permission of the teacher;
- in lectures it is forbidden to engage in activities that do not directly relate to the course;
- laboratory work takes place in the form of a computer workshop;
- only students who are ready to defend their work should be present at laboratory classes;

- during the defense of the laboratory work the student must demonstrate the completed task and answer the teacher's questions (questions from the theory, practical task, etc.);
- options (if the division into options is provided in the task) for laboratory work are selected as follows: the first 15 students receive options according to the number in the group list, the student with number 16 in the list receives option 1, etc.
- penalty points for late protection of laboratory work are not accrued;
- it is possible to defend laboratory works in any sequence;
- repeated protection of laboratory works is prohibited;
- it is forbidden to use outside help during the defense of laboratory work.

8. Monitoring and grading policy

The final rating of a student in the course "Basics of computer systems and networks" consists of points that he receives:
- for academic work during the semester (starting scores);
- for exam.

8.1. Getting of starting scores.
During the semester the student performs 9 laboratory works.
For each laboratory work the student receives:
- 6 scores for completed in full and without significant errors task for laboratory work;
- from 0 to 4 scores for the defense of laboratory work, which consists of theoretical questions, practical tasks.
1 modular test is planned, for which the student can receive from 0 to 16 points.
The student's starting scores are calculated as the sum of scores for all laboratory works and modular test multiplied by a coefficient of 0.6.

8.2. Conditions for admission to the exam.
To obtain admission to the exam student must defend 9 laboratory works.

8.3. Scoring for the exam.
In the exam, students must answer three theoretical questions. Each theoretical question is evaluated in 20 score.
Theoretical evaluation system:
18-20 score - complete answer (not less than 90% of the required information);
15-17 score - a fairly complete answer (at least 75% of the required information, or minor inaccuracies);
12-14 score - incomplete answer (at least 60% of the required information and some errors);
0 score - unsatisfactory answer (less than 60% of the required information or significant errors).

The sum of starting score and score for the exam are adopted by university grading system as follows:

Score	Grade
100-95	Excellent
94-85	Very good
84-75	Good
74-65	Satisfactory
64-60	Sufficient
Below 60	Fail

Course requirements are not met	Not Graded

9. Additional information about the course

During lectures, in addition to presentations, it is necessary to use software to demonstrate the operation of network services. This will give the student the opportunity to learn the lecture material more deeply.

9.1. List of theoretical questions for the exam.

- Open systems interaction reference model (ISO/OSI).
- The multi-level structure of the TCP/IP suite.
- Application layer.
- Transport layer.
- Network layer.
- Network interfaces layer.
- TCP/IP suite layers and ISO/OSI model.
- The main protocols of the TCP/IP suite, their purpose.
- IP packet format for the 4th and 6th versions of the protocol.
- IP packet fragmentation for the 4th version of the protocol.
- Classes of IP addresses.
- Special purpose IP addresses.
- ICMP protocol.
- ARP protocol.
- Scheme of operation of the DHCP protocol.
- DHCP message.
- Distance-vector routing algorithms.
- Link state routing algorithms.
- RIP protocol.
- OSPF protocol.
- Media access control.
- Switch architecture.
- Group of IEEE802.3 standards.
- IEEE802.11 standard wireless local networks.
- UDP protocol.
- TCP protocol.
- TCP header format.
- Flow control in TCP.
- Congestion control in TCP.
- NAPT work scheme.
- Types of firewalls.

- Stateful network filter.
- Types of virtual private networks.
- Layers of VPN implementation.
- IPSec protocol.
- Client-server architecture.
- Peer-to-peer architecture.
- Berkeley sockets.

9.2. Additional Information Resources

https://www.cs.vu.nl/~ast/CN5/

Syllabus of the course

Is designed by teacher Associate Professor, Ph.D, Oleksandr Rokovyi

Adopted by Department of Computing Engineering (protocol № 13, 10 May 2023)

Approved by the Faculty Board of Methodology (protocol № 11, 29 June 2023)