DESIGN OF HEAT EXCHANGE EQUIPMENT

Working program of the academic discipline (Syllabus)

Details of the academic discipline

Level of higher education	***First (undergraduate)***
Branch of knowledge	*13 Mechanical engineering*
Specialty	*133 Industrial engineering*
Educational program	*Computer-integrated technologies of chemical engineering equipment design*
Discipline status	*Selective*
Form of education	*daytime*
Year of training, semester	*3rd year, spring semester, 2nd year accelerators, spring semester*
Scope of the discipline	*4 credits*
Semester control/ control measures	*Final score, MKR*
Lessons schedule	*http://rozklad.kpi.ua/Schedules/ScheduleGroupSelection.aspx*
Language of teaching	*Ukrainian*
Information about head of the course / teachers	*Lecturer/Practical:associate professor of the Department of the National Academy of Sciences of the Russian Academy of Sciences, candidate of technical sciences, Associate Professor A.R. Stepanyuk, < arstepaniuk@gmail.com >*
Placement of the course	https://ci.kpi.ua/uk/syllabuses-bac-disciplines/#place

Program of educational discipline

Description of the educational discipline, its purpose, subject of study and learning outcomes
The purpose of the educational discipline.
The purpose of the educational discipline is to form students' competence:

- *Ability to think systematically.*
- *Ability to plan and manage time.*
- *Ability to search, process and analyze information from various sources.*
- *Ability to apply knowledge in practical situations.*
- *Ability to learn and master modern knowledge.*
- *Ability to generate new ideas (creativity).*
- *Ability to think systematically.*
- *Ability to achieve set goals.*
- *The ability to take initiative and a creative approach when solving tasks.*
- *The ability to express one's point of view in a reasoned, convincing and understandable way.*
- *Ability to work with information (search, process, evaluate, use, edit, design, present, etc.).*
- *Ability to apply typical analytical methods, quantitative methods of mathematics, physics, engineering sciences, as well as computer software tools for effective solving of chemical engineering problems.*
- *Ability to apply fundamental scientific facts, concepts, theories, principles to solve professional tasks and practical problems in chemical engineering.*
- *The ability to evaluate and ensure the quality of the work performed.*

- *The ability to use knowledge of the physical foundations of mechanical, hydromechanical, heat and mass exchange processes when solving professionally oriented tasks.*
- *The ability to determine the parameters of chemical and technological processes and to make a rational choice of equipment for their implementation and to determine the modes of its operation in given production conditions.*

1.2. The main tasks of the academic discipline.

After mastering the academic discipline, students must demonstrate the following learning outcomes:

- *To know and understand the principles, approaches and methods of engineering equipment of chemical and related technologies and the prospects of their development, to be able to analyze engineering objects, processes and methods.*
- *Be able to make creative decisions when designing, develop new and improve known elements of technological equipment.*
- *Apply means of technical control to evaluate the parameters of objects and processes during the manufacture and operation of equipment of chemical and related technologies.*
- *To understand the physical essence of the phenomena, mechanisms of chemical transformations carried out in the equipment of chemical and related technologies, to apply the mathematical apparatus for quantitative calculations, on the basis of which to choose the parameters of the equipment and its modes of operation.*

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

The list of disciplines, the mastery of which is necessary for the student (requirements for the level of preparation) for successful mastering of the discipline:

- *Processes and equipment of chemical technologies*

the list of disciplines that are based on the results of training in this discipline.:

- *Pre-diploma practice*
- *Diploma design*
- *Basics of three-dimensional design*

2. Content of the academic discipline

Section1 CLASSIFICATION OF FURNACES AND THEIR MAIN SCHEMES

Topic 1.1 General diagram of the furnace. Heat engineering processes in furnaces.Classification of furnaces. Classification of tubular furnaces.

The definition of industrial heat energy generation devices and their main characteristics is given. The general scheme of the furnace is studied. Thermal engineering processes in furnaces are analyzed. The classification of furnaces of the chemical industry according to the following features is presented: by types of production, technological classification, by thermal technical features, by structural features. The classification of tubular furnaces is given

Chapter 2 CHARACTERISTICS OF FUELS AND FEATURES OF THEIR COMBUSTION

Topic 2.1 Characteristics of fuels used in industrial furnaces. Fuel burning.

The characteristics of fuels are given, the classification of fuel types is presented, the composition of fuels used in industrial furnaces is evaluated.

Topic 2.2 Calculation of the amount of air for combustion. Combustion temperatures, thermal efficiency of fuel.

The theoretical amount of air for burning solid, liquid and gaseous fuels is determined. The amount of gases formed during the combustion of 1 kg of fuel and the elemental composition of gaseous fuel are determined. The concepts of higher and lower heat of combustion of fuel, calorimetric, theoretical and actual temperature of combustion of fuel and heat equivalents of various fuels are given

Chapter 3 FURNACES AND DEVICES FOR COMBUSTION OF FUEL

Topic 3.1 Peculiarities of burning fuel in furnaces. Classification of stoves for solid fuel.

Homogeneous and heterogeneous processes are defined, and their examples are given. The classification of furnaces for solid fuel from the point of view of the aerodynamic characteristics of the movement of fuel and gases is given

Topic 3.2 Features of burning solid fuel. Features of burning coal dust. Burners for burning coal dust.

Hypotheses of the process of carbon oxidation are presented. Equations for the oxidation of carbon by water vapor are given. The heterogeneous combustion scheme is analyzed. The pulverized coal burning process and burning time are analyzed. Burners for burning coal dust are analyzed.

Topic 3.3 Combustion of liquid fuel in furnaces. Spraying fuel.

Classification of fuel oils and their thermophysical characteristics are taught. Methods of rational use of high-sulfur fuel oil are given. Schemes of burning a stationary drop and burning fuel oil with the help of nozzles are given. Schemes of spraying nozzles and designs of mechanical nozzles are given.

Topic 3.4 Calculation of nozzles for fuel oil.

Dependencies are given for the calculation of mechanical and low-pressure air nozzles, high-pressure air nozzles and steam nozzles.

Topic 3.5 Peculiarities of gaseous fuel combustion. Kinetic and diffusion areas of combustion.

Ignition conditions, ignition temperatures, and ignition concentration limits of gaseous fuel are determined. The kinetic and diffusion regions of combustion are determined.

Topic 3.6 Torch process of burning gaseous fuel. Regularities of the flare process of gaseous fuel combustion.

A diagram of a free gas stream is presented, the parameters of the torch during the combustion of gaseous fuel are determined. The influence of the parameters of the combustion process on the length of the torch is determined.

Topic 3.7 Burners for burning gaseous fuel.

The purpose of gas burners is given and the methods of creating a combustible mixture are substantiated. The main designs of burners for burning gaseous fuel are explained.

Chapter 4 HEAT EXCHANGE IN FURNACES

Topic 4.1 Heating the material in the furnace. External and internal heat exchange. Heat transfer by convection. Heat transfer of heat by radiation. Heat absorption by a bundle of radiant tubes. Heat exchange in a tubular furnace.

The process of heat transfer in furnaces is substantiated. The definition of external and internal heat exchange, heat transfer by convection and radiation is given. Concepts of absolutely black, absolutely white, transparent, gray, colored and selective bodies are given. Issues of heat absorption by a bundle of radiant tubes and features of heat exchange in tube furnaces are considered.

Chapter 5 MOVEMENT OF GASES IN FURNACES

Topic 5.1 Pressure losses.

The concepts of natural and forced traction are given. General or frictional pressure losses and pressure losses on local supports and features of the chimney calculation are considered.

Chapter 6 TECHNICAL AND ECONOMIC INDICATORS OF FURNACE OPERATION

Topic 6.1 Material balance of the furnace. Heat balance of the furnace. Expenditure articles of heat balance. The main thermotechnical characteristics of furnace operation.

Features of material and heat balances of technological processes taking place in furnaces and heat balance of furnaces, which are related to production indicators of furnaces, are given. Expenditure articles of the heat balance of furnaces and the main thermotechnical characteristics of furnace operation are considered.

3. Educational materials and resources

5.1. Basic

1. *Furnace equipment in chemical and oil refining processes [Electronic resource]: training. manual / A.R. Stepaniuk – Kyiv: KPI named after Igor Sikorskyi, 2017 – 172 p. Access from the screen:http://si.kpi.ua*
2. *Kornienko Y.M. Processes and equipment of chemical technology 1: textbook /Y.M. Kornienko, Yu.Yu. Lukach, I.O. Mikulonok, V.L. Rakytskyi, G.L. Ryabtsev - K.: NTUU "KPI", 2011 - Part 1 - 300 p.*

3. *Kornienko Y.M. Processes and equipment of chemical technology 2: textbook /Y.M. Kornienko, Yu.Yu. Lukach, I.O. Mikulonok, V.L. Rakytskyi, G.L. Ryabtsev - K.: NTUU "KPI", 2011 - Part 2 - 416 p.*

5.2. Auxiliary

4. *Calculations of heating furnaces. S.I. Averin, E.M. Goldfarb, A.F. Kravtsov et al./ edited by N.Yu. Thai - Kyiv, "Technique", 1969.*

Educational content

4. Methods of mastering an educational discipline (educational component)

Lecture classes

Lectures are aimed at:

- *provision of modern, comprehensive in-depth knowledge of the discipline, the level of which is determined by the target attitude to each specific topic;*
- *provision of critical creative work together with the teacher in the process of work;*
- *education of acquirers of professional qualities and development of their independent creative thinking;*
- *awareness of world trends in the development of science in the field of processes and technology of heat exchange equipment;*
- *awareness of the methods of processing information resources and determining the main directions for solving specific scientific and technical problems;*
- *teaching research materials in a clear and high-quality language in compliance with structural and logical connections, clarification of all given terms and concepts available for perception by the audience.*

No s/p	The name of the topic of the lecture and a list of the main questions (a list of didactic tools, references to the literature and tasks on the SRS)	Number hours
	Section1 CLASSIFICATION OF FURNACES AND THEIR MAIN SCHEMES	
	Topic 1.1 General diagram of the furnace. Heat engineering processes in furnaces.Classification of furnaces. Classification of tubular furnaces.	
1	*The definition of industrial heat energy generation devices and their main characteristics is given. The general scheme of the furnace is studied. Thermal engineering processes in furnaces are analyzed. The classification of furnaces of the chemical industry according to the following features is presented: by types of production, technological classification, by thermal technical features, by structural features. The classification of tubular furnaces is given.* *Literature 1, 2, 3.*	2
	Chapter 2 CHARACTERISTICS OF FUELS AND FEATURES OF THEIR COMBUSTION	
	Topic 2.1.Characteristics of fuels used in industrial furnaces.	
	are givencharacteristics of fuels used in industrial furnaces. *Literature 1, 2, 7.*	2
	Topic 2.3.Calculation of the amount of air for combustion. Combustion temperatures, thermal efficiency of fuel.	
2	*They are analyzedamount of air for combustion. Combustion temperatures, thermal efficiency of fuelfuel burning* *Literature 1, 2, 3.*	2
	Chapter 3 FURES AND DEVICES FOR COMBUSTION OF FUEL	
	Topic 3.1Features of burning fuel in furnaces.Classification of stoves for solid fuel.Features of burning solid fuel.Features of burning coal dust.Burners for burning coal dust.	
3	*The peculiarities of burning fuel in furnaces are substantiated. The classification of stoves for solid fuel is given. The specifics of burning solid fuel and the specifics of burning coal dust are substantiated. Designs of burners for burning coal dust are given.* *Literature 1, 2, 3.*	2
	Topic 3.2Combustion of liquid fuel in furnaces.Injectors for liquid fuel.Calculation of nozzles for fuel oil	
4	*Combustion of liquid fuel in furnaces and atomization of fuel is analyzed. The calculation algorithm for fuel oil nozzles is given. The peculiarities of gaseous fuel combustion, the kinetic and diffusion regions of combustion are analyzed.* *Literature 1, 2, 3.*	2
	Topic 3.3Peculiarities of gaseous fuel combustion.Kinetic and diffusion areas of combustion.Flare process of burning gaseous fuel.Regularities of the flare process of gaseous fuel combustion.Burners for burning gaseous fuel.	
	The flaring process of burning gaseous fuel is substantiated. The regularities of the flare process of gaseous fuel combustion are analyzed. Burners for burning gaseous fuel are characterized.	2
	Topic 3.4. The choice of traction-spiritual devices.	
5	*The peculiarities of the choice of traction-spirit devices are substantiated.* *Literature 1, 2, 3.*	
	Chapter 4 HEAT EXCHANGE IN FURNACES	
	Topic 4.1 Heating the material in the furnace. External and internal heat exchange. Heat transfer by convection. Heat transfer of heat by radiation. Heat absorption by a bundle of radiant tubes. Heat exchange in a tubular furnace.	

6	*The process of heat transfer in furnaces is substantiated. The definition of external and internal heat exchange, heat transfer by convection and radiation is given. Concepts of absolutely black, absolutely white, transparent, gray, colored and selective bodies are given. Issues of heat absorption by a bundle of radiant tubes and features of heat exchange in tube furnaces are considered.* *Literature 1, 2, 3.*	*2*
	Topic 4.2. Features of internal heat exchange calculation.	
7	***The peculiarities of internal heat exchange calculation are substantiated*** ***Literature 1, 2, 3.***	
	Chapter 5 MOVEMENT OF GASES IN FURNACES	
	Topic 5.1 Pressure losses. Smoke extractors Basics of calculating smoke extractors.	
8	*The concepts of natural and forced traction are given. General or frictional pressure losses and pressure losses on local supports and features of the chimney calculation are considered.* *Literature 1, 2, 6.*	*2*
	Chapter 6 TECHNICAL AND ECONOMIC INDICATORS OF FURNACE OPERATION	
	Topic 6.1 Material balance of the furnace. Heat balance of the furnace. Expenditure articles of heat balance. The main thermotechnical characteristics of furnace operation.	
	Features of material and heat balances of technological processes taking place in furnaces and heat balance of furnaces, which are related to production indicators of furnaces, are given. Literature 1, 2.	*2*
9	*Modular control work.*	*2*
	Test	*2*

Practical training

- *Applicants should be helped to develop creative thinking, a creative approach to the scientific substantiation of the research direction and methodology. The main tasks of the cycle of practical classes:*
- *help applicants to deepen their theoretical knowledge in the field of processes and technology of primary gas and oil refining;*
- *to promote the training of applicants in the methodology of determining the properties of fuels;*
- *form criteria for evaluating the effectiveness of processes of special methods of thermal preparation.*

No s/p	***The name of the subject of the practical session and a list of the main questions (list of didactic support, references to the literature and tasks on the SRS)***	***Number hours***

No s/p	***The name of the subject of the practical session and a list of the main questions (list of didactic support, references to the literature and tasks on the SRS)***	***Number hours***
	Chapter 2 CHARACTERISTICS OF FUELS AND FEATURES OF THEIR COMBUSTION	
1-2	*Topic 2.1 Characteristics of fuels used in industrial furnaces. Fuel burning. Calculation of the amount of air for combustion. Combustion temperatures, thermal efficiency of fuel.*	
	Calculation of carbon content in fuel components	*4*
	Literature 1, 2, 3, 7.	
3-4	*Topic 2.1.Characteristics of fuels used in industrial furnaces.*	
	Calculation of heat of combustion of coal. Determination of heat of combustion of coking gas.	*4*

	Literature 1, 2, 3, 7.	
	Topic 2.2.Fuel burning.	
5-6	*Determination of heat of combustion of coking gas.*	*4*
	Literature 1, 2, 3, 7.	
	Topic 2.3.Calculation of the amount of air for combustion. Combustion temperatures, thermal efficiency of fuel	
7-8	*Calculation of the amount of air for combustion*	*4*
	Literature 1, 2, 3, 7.	
	Chapter 3 FURES AND DEVICES FOR COMBUSTION OF FUEL	
	Topic 3.2 Calculation of nozzles for fuel oil. Burners for burning gaseous fuel.	
9-10	*Calculation of a mechanical nozzle*	*4*
	Calculation of a low-pressure burner for burning fuel oil	
	Literature 8.	
	Topic 3.3.Peculiarities of gaseous fuel combustion.Kinetic and diffusion areas of combustion.Flare process of burning gaseous fuel	
11-12	*Calculation of an injector panel torchless burner*	*4*
	Literature 8.	
	Topic 3.4. The choice of traction-spiritual devices.	
13-14	*Calculation of the traction device for the furnace installation*	*4*
	Literature 8.	
	Chapter 4 HEAT EXCHANGE IN FURNACES	
	Topic 4.1 External and internal heat exchange. Heat exchange by heat transfer, convection and radiation.	
15-16	*Calculation of the heat transfer of the oven. Calculation of the main dimensions of the mine furnace*	*4*
	Literature 8.	
	Topic 4.2. Features of internal heat exchange calculation.	
17-18	*Calculation of furnace insulation.*	*4*
	Literature 8.	

6. Independent work of student

Independent work makes up 50% of the study of the credit module, which includes preparation for the credit. The main task of independent workacquirers- this is the deepening of worldview and scientific knowledge in the directions specified in the lectures, through the search for necessary information, the formation of perseverance and creative search in the formation of working hypotheses for the intensification of transfer processes.

Policy and control

7. Policy of academic discipline (educational component)

Rules of attending classes and behavior in classes

Attending classes is mandatory.Gettersare obliged to take an active part in the educational process, not to be late for classes and not to miss them without valid reasons, not to interfere with the teacher conducting classes and not to be distracted by actions unrelated to the educational process.

Rules for assigning incentive and penalty points

- *incentive points can be awarded by the teacher exclusively for the performance of creative works and working hypotheses.*
  But their sum cannot exceed 25% of the rating scale.
- *Penalty points are not provided within the academic discipline.*

Policy of deadlines and rescheduling

In case of academic debts arising from the academic discipline or any force majeure circumstances,acquirersshould contact the teacher to coordinate the algorithm of actions related to solving existing problems.

Policy of academic integrity

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism refers to the absence of references when using printed and electronic materials, quotes, opinions of other authors. Inadmissible tips and write-offs during writing tests, conducting classes.
The policy and principles of academic integrity are defined in Chapter 3 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute". More details:https://kpi.ua/code

Policy of academic behavior and ethics

Gettersmust be tolerant, respect the opinion of others, formulate objections in the correct form, adequately support feedback during classes.
Standards of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute". More details:https://kpi.ua/code

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

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

Semester	Training time		Distribution of study hours				Control measures			
	Credits	Acad. hours	Lectures	Practical	Lab. do	SRS	MKR	RR	Abstract	Semester control
8	4	120	18	36	–	66	6	–	6	test

The student's rating in the discipline consists of the points he receives for:

The rating of the applicant from the credit module consists of the points he receives for work in practical classes, lectures and MKR.

Semester control is an exam.

System of rating (weighted) points and evaluation criteria

Systemrating points and evaluation criteria:

A weighted point for questions in lectures is 1 point

The weighted score for practical classes is 4 points each;

The weighted score for MKR is 28 points

Criteria for evaluating the performance of a practical task

Completeness and signs of task completion	***Points***
The task is fully completed	*4*
Minor defects according to point 1	*3*
Untimely completion of the task	*2.5*

Untimely completion of the task, deficiencies under clause 1	*2*
Poor performance of the task	*1*
Failure to complete the task	*0*

Thus, the rating semester scale from the credit module is:

R =8 1+ 3 18 +1 38=18+54+28 = 100 points

According to the results of the educational work in the first 7 weeks, the "ideal acquirer" should score 40 points. At the first attestation (8th week), the applicant receives "credited" if his current rating is at least 20 points.

According to the results of the educational work for 13 weeks of training, the "ideal achiever" should score 90 points. At the second attestation (14th week), the applicant receives "credited" if his current rating is at least 40 points.

The maximum number of points is 100. To receive credit from the credit module "automatically" you need to have a rating of at least 60 points.

A necessary condition for admission to credit is a rating of at least 40% of the rating scale (R), i.e. 40 points.

Getters, who gained a rating of less than 0.6 R during the semester, as well as those who want to improve the overall rating, complete a credit test. At the same time, all the points they received during the semester are cancelled. Test tasks contain questions that refer to different sections of the credit module. The list of assessment questions is given in Chapter 9.

To obtain a passing grade, the sum of all rating points R received during the semester is converted according to the table:

Scores	***Rating***
95...100	*perfectly*
85...94	*very good*
75...84	*fine*
65...74	*satisfactorily*
60...64	*enough*
RD<60	*unsatisfactorily*
Admission conditions not met	*not allowed*

9. Additional information on the discipline (educational component)

An approximate list of questions submitted for semester control

The ticket consists of three questions

- *What is an industrial furnace.*
- *Schematic diagram of a fuel furnace.*
- *Main and auxiliary equipment of industrial furnaces.*
- *Classification of industrial furnaces by types of production.*
- *Classification of industrial furnaces by production organization.*
- *Classification of industrial furnaces according to thermal parameters.*
- *The main methods of obtaining thermal energy in electric furnaces.*
- *What is fuel?*
- *Classification of fuels.*
- *Main fuel characteristics.*
- *Fuel classification by origin and condition. Examples.*
- *Features of fuel combustion in industrial furnaces.*

- *High-quality composition of solid and liquid fuels.*
- *Recalculation of the composition of solid and liquid fuel from organic and dry mass to working.*
- *Recalculation of gaseous fuel from dry weight to operating weight.*
- *The sequence of fuel combustion calculation.*
- *Ignition temperature.*
- *What are flash concentration limits.*
- *Fuel calorific value, its size and what characteristics affect its size.*
- *Higher and lower calorie content (Qнр and Qвр), the difference between them.*
- *Thermal equivalent, conventional fuel.*
- *Stoichiometric ratio of fuel and air.*
- *A mixture of fuel with a given heat of combustion. Calculation procedure.*
- *The required amount of dry air for CO combustion.*
- *The required amount of dry air for burning H2.*
- *The required amount of dry air for burning CH4.*
- *The coefficient of air flow in different cases of fuel combustion.*
- *Theoretical and actual amount of air for combustion*
- *Inflammation.*
- *How to achieve ignition.*
- *Burning temperature.*
- *How to raise the calorimetric temperature of combustion.*
- *How to raise the actual burning temperature.*
- *Determining the air flow rate based on the composition of combustion products.*
- *Methods of determining the calorific value of fuel.*
- *Homogeneous and heterogeneous combustion.*
- *Features of burning solid fuel.*
- *What limits the burning of solid fuel.*
- *Types of stoves for burning solid fuel.*
- *Features of burning liquid fuel.*
- *What limits the burning of liquid fuel.*
- *Selection and calculation of structural parameters of furnaces.*
- *How to increase the viscosity of liquid fuel.*
- *The main methods of spraying liquid fuel.*
- *Purpose of nozzles.*
- *The main methods of spraying liquid fuel in nozzles.*
- *Selection and calculation of design parameters of nozzles.*
- *Peculiarities of gaseous fuel combustion.*
- *What limits the burning of gaseous fuel.*
- *Diffusion combustion.*
- *Kinetic principle of combustion.*
- *The main ways of forming a mixture of fuel and oxidizer in burners.*
- *Selection and calculation of design parameters of burners.*
- *Factors affecting the length and shape of the flame.*
- *External mixing of gas and air, length of the torch.*
- *Complete internal mixing of gas and air; torch length.*
- *Ways of torch stabilization.*
- *Types of heat transfer.*
- *The main directions of heat utilization and fuel saving in industrial furnaces.*
- *What are recuperator and regenerator. The main differences between them.*
- *Known designs of recuperators and regenerators*
- *The main directions of heat utilization and fuel saving in industrial furnaces.*

- *Movement of gases and materials in furnaces. Types of gas movement.*
- *Movement of gases in the layer and channel. Stream aerodynamics.*
- *Thrust in furnace installations. Basics of pressure loss calculation.*
- *Calculation of chimneys, smoke pipe and injectors. The choice of traction-spiritual devices.*
- *External and internal heat exchange.*
- *Heat exchange by heat transfer, convection and radiation.*
- *Heat exchange by heat transfer, convection and radiation.*
- *Features of internal heat exchange calculation.*
- *Technical and economic performance indicators of furnaces.*
- *Thermal and material balances.*
- *Specific consumption of thermal energy. Efficiency and fuel efficiency.*

Working program of the academic discipline (syllabus):

Compiled by associate professor of the Department of the Moscow State University, candidate of technical sciences, associate professor Andrii Stepaniuk

Approved by the Department of the Academy of Medical Sciences (protocol No. 20 dated June 20, 2022)

Agreed by the Methodical Commission of the faculty (protocol No. 10 dated 24.06.2022)