- Academic discipline requirements

Level of higher education	*First (bachelor's)*
Discipline	*13 Mechanical Engineering*
Specialty	*133 Industrial mechanical engineering*
Educational program	*Name*
Discipline status	*Regulatory*
Form of study	*full-time (day)*
Year of training, semester	*3rd year, fall*
Scope of the discipline	*6 credits*
Semester control/control measures	*Exam, MCR, current control*
Class schedule	
Language of instruction	*Ukrainian*
Information about the course leader/teachers	Lecturer: Candidate of Technical Sciences, Associate Professor, Shved Mykola Petrovych, npchved46@gmail Practical: Candidate of Technical Sciences, Associate Professor Novokhat Oleg Anatolievich Laboratory Candidate of Technical Sciences, Associate Professor Oleg Anatolyevich Novokhat
Course placement	Campus Link to remote resource (Moodle, Google classroom, etc.))

- Academic discipline program

Description of the academic discipline, its purpose, subject of study and learning outcomes

The technology for manufacturing products in the chemical, oil refining, biotechnological, food, and other industries is built as a sequence of a limited number of basic processes that occur under different conditions (temperature, pressure, concentration, etc.). These processes include mechanical, hydromechanical, thermal, mass-exchange, diffusion-controlled, and chemical processes, which are based on the fundamental laws of conservation of energy, mass, and momentum.

Chemical and oil refining processes and equipment is a branch of science and technology that studies the main characteristics of micro- and macrokinetics of chemical and technological processes and establishes the parameters that are the conditions for their implementation in the corresponding equipment. A decisive role is played by physical and mathematical modeling of processes, in particular using automated modeling, calculation and design systems, which allow for the transition from laboratory and theoretical research to the implementation of processes in industrial equipment (large-scale transition).

The discipline is based on the knowledge gained by students while studying academic disciplines of the humanitarian, natural science and professional-practical cycles, namely higher mathematics, physics, chemistry, physical chemistry, theoretical mechanics, resistance of materials, theoretical foundations of heat engineering, hydraulics, descriptive geometry, engineering and computer graphics.

1. Description of the credit module

Level of higher education, specialty, educational program, form of study	General indicators	Characteristics of the credit module
Level of VO first (bachelor's)	Name of the discipline, Chemical technology processes and equipment – 1. Thermal processes	Lectures 54 hours
specialty 133 Industrial mechanical engineering	Professional training cycle	Practical 36 hours.
Educational program Equipment for chemical, oil refining and pulp and paper industries	Credit module status – mandatory	Laboratory work 6pm.
Form of study daytime	Semester 5	Independent work 132 hours,
		Individual task
	Number of credits (hours) 8(240)	Type and form of semester control exam

Subject of the academic discipline– chemical production processes and equipment

Mastering the material of the discipline will allow you to master the basic theoretical principles of hydromechanical processes and thermal processes, master the methods and techniques of assessing their efficiency, and be able to justify technical solutions to increase their efficiency.

This will contribute to increasing the competitiveness of specialists when employed in prestigious engineering positions.

The purpose of the academic discipline

The purpose of the academic discipline is to develop students' abilities to:

- to the analysis of the design features of chemical equipment;
- to the design of chemical equipment;
- to the selection of chemical equipment elements;
- to the selection of energy carriers and the determination of their energy parameters.

1.2. Main objectives of the academic discipline.

According to the requirements of the educational and professional program, students, after mastering the academic discipline, must demonstrate the following learning outcomes:

knowledge:

- main chemical and technological processes and their classification;
- designs of heat exchange equipment;
- calculation methods and basic dimensions and technical parameters of heat exchange equipment;
- sources of thermal energy supply;
- directions for saving thermal energy and increasing the reliability of heat exchange equipment;
- design diagrams of thermal equipment for the implementation of certain processes of the technological scheme;

skills:

- using data on the main features of heat exchange equipment

to classify them;

- using data on the basic properties of energy carriers, calculate their main parameters;
- using data on the basic needs of technological processing, select the appropriate design of heat exchange equipment;
- using data on the designs and technological characteristics of heat exchange equipment, calculate their main dimensions and technical parameters using appropriate methods;
- using data on the designs of heat exchange equipment;

and technological characteristics of the processes taking place in them, to assess the technical and economic feasibility of sources of thermal energy supply;

- using data on technical and economic indicators of heat exchange equipment

determine the main areas of thermal energy saving;

- based on the analysis of options, make a rational choice of design schemes of thermal equipment for the implementation of certain processes of the technological scheme;
- during the development of a technical proposal, draft and technical projects and working design documentation, using the methods and techniques of engineering and computer graphics, the principles of interchangeability and the system of tolerances and fits, to perform assembly drawings of heat exchange equipment;
- using methods and computing technology, perform material and heat balances of equipment, calculate kinetic characteristics of processes and basic geometric dimensions of devices;
- knowing the basic designs of equipment, be able to develop design documentation for heat exchange equipment;

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experience:

- design or verification calculation of heat exchange equipment;
- structural calculation of heat exchange equipment;
- determination of the characteristics of coolants;

Program learning outcomes, assessment measures, and deadlines are announced to bachelors at the first lesson.

2. Purpose and objectives of the credit module

2.1 The purpose of the credit module is to develop students' abilities to:

- the ability to solve problems in the design, maintenance, modernization and disposal of chemical and oil refining equipment, taking into account the basic principles of the theory of heat and mass transfer;

- the ability to solve problems in the selection and preparation of raw materials, production of products and waste disposal of chemical and oil refining industries, taking into account the basic principles of the theory of heat and mass transfer.

2.2 Main tasks of the credit module

According to the requirements of the academic discipline program, students must demonstrate the following learning outcomes after completing the credit module:

KNOWLEDGE:

- modern approaches, methods and techniques, solving problems in the design, maintenance, modernization and disposal of waste from chemical and oil refining industries, taking into account the basic principles of the theory of heat and mass transfer;
- modern approaches, methods and techniques, solving problems in the selection and preparation of raw materials, obtaining products and disposing of waste in chemical and oil refining industries, taking into account the basic principles of the theory of heat and mass transfer.

SKILLS:

- using scientific and technical information, regulatory documents, and professional knowledge, solve problems in the design, maintenance, modernization, and disposal of chemical and oil refining equipment, taking into account the basic principles of the theory of heat and mass transfer;
- using scientific and technical information, regulatory documents, and professional knowledge, independently solve problems in the design and modernization of chemical and oil refining equipment, taking into account the basic principles of the theory of heat and mass transfer;
- using scientific and technical information, regulatory documents, and professional knowledge, solve problems in the selection and preparation of raw materials, production of products, and waste disposal of chemical and oil refining industries, taking into account the basic principles of the theory of heat and mass transfer;
    - apply computer engineering methods using special software to perform computer design of equipment for chemical and oil refining industries, taking into account the basic principles of the theory of heat and mass transfer;

- Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of study according to the relevant educational program)

A list of disciplines, or knowledge and skills, the mastery of which is necessary for the student (requirements for the level of preparation) for the successful mastery of the discipline is indicated (for example, "basic level of English proficiency not lower than A2"). A list of disciplines that are based on the results of learning in this discipline is indicated.

Interdisciplinary connections, list of disciplines preceding the academic discipline:

- Occupational safety and civil protection.
- Technology of structural materials.
- Materials science.
- Theoretical mechanics.
- Mechanics of materials and structures.
- Theory of mechanisms and machines.
- Metrology and standardization.
- Machine parts.
- Theoretical foundations of heat engineering.

List of disciplines provided by this academic discipline:

- Calculation and design of typical equipment.
- Educational disciplines in calculation and modeling using a PC.
- Academic disciplines in computerized engineering.
- Educational disciplines in three-dimensional modeling.
- Educational disciplines on means of delivery and movement.
- Educational disciplines on heat treatment and processing processes.
- Educational disciplines in process management.
- Educational disciplines on equipment preparation and operation.

• Content of the academic discipline

• The structure of the credit module

Chapter and topic names	Number of hours				
	Total	including			
		Lectures	Practical (seminar)	Laboratory (computer lab)	CRC
1	2	3	4	5	6
Chapter 1 Transfer phenomena in chemical production processes and devices.					
Topic 1.1 Introduction to the course of processes and apparatus.	2	2		-	-
Topic 1.2. Transfer phenomena in chemical technology.	8	6	-	-	2
Topic 1.3. Fundamentals of similarity theory.	6	4			2
Total under section 1	16	12			4
Chapter 2. Fundamentals of Heat Transfer					
Topic 2.1. Thermal conductivity.	18	4	4	4	6
Topic 2.2. Convective heat transfer.	20	8	4	4	4
Topic 2.3. Heat transfer during a change in the state of aggregation.	12	4	4		4
Topic 2.4. Heat transfer by radiation.	5	2			3
Topic 2.5. Complex heat transfer	11	4	4	-	3
Topic 2.6. Non-stationary thermal conductivity	11	4		4	3
Together under section 2	77	26	16	12	23
Section 3. Heat exchange equipment					

Topic 3.1. Heating and cooling in chemical technology.	26	6	8-	8	4
Topic 3.2 Evaporation and evaporation plants in chemical technology.	22	4	6	8	4
Topic 3.3 Drying and drying plants in chemical technology.	22	4	6	8	4
ICR for sections 1,2,3.	2	2		-	
Calculation work	15	-	-	-	15
Exam preparation	30	-	-	-	30
Together under section 3	117	16	20-	24	57
Together according to section 1,2,3	210	54	36	36	84

Chapter 1. Fundamentals of Transference Theory

Topic 1.1. Introduction to the course of processes and devices.

Introduction. Course goals and objectives. Classification of processes. Generalized technological scheme and principles of its construction for a specific product.

Transfer phenomena in chemical technology. Equations of conservation of mass, energy, momentum. Principles of their solution.

Physical fields. Density of mass and energy flows, gradients of temperatures, concentrations, and speeds.

Principle of solving transport equations. Conditions of uniqueness.

Topic 1.2 Similarity theory. Criterion equations and the principle of their derivation.

Similarity theory. Similarity theorems. Criterion equations and criteria for thermal and hydrodynamic similarity.

Section 2. Technical hydraulics

Topic 2.1. The basic equation of hydrostatics. The momentum transfer equation and its analysis.

The basic equation of hydrostatics. The momentum transfer equation and its analysis. The Euler and Navier-Stokes equations.

Topic 2.2. Bernoulli's equation. Frictional resistance and local resistance. Their calculation.

Bernoulli's equation. Frictional resistance and local resistance. Their calculation. Classification and principle of operation of hydraulic machines.

Chapter 3. Fundamentals of Heat Transfer

Topic 3.1. Diffusion energy transfer.

Thermal conductivity. Differential equation. Uniqueness conditions. Partial cases of solving the thermal conductivity equation.

Thermal conductivity under boundary conditions of the third kind. The basic heat transfer equation and its analysis.

Topic 3.2. Convective heat transfer.

Convective heat transfer. Mathematical model. Thermal similarity criteria. Criterion equations.

Heat transfer during forced and free convection.

Topic 3.3. Heat transfer during a change in the state of aggregation and radiation.

Features of heat transfer during a change in the state of aggregation. Droplet and film condensation. Criteria equations of condensation.

Boiling. Boiling modes. Calculation of the heat transfer coefficient during boiling.

Heat transfer by radiation. Basic laws. Heat transfer between solids and between a gas and a solid.

Section 4. Heat exchange equipment

Topic 4.1. Heat exchangers.

Heat carriers and their properties. Heating and cooling methods. Classification of heat exchangers. Average driving force and its definition.

Classification and calculation methods of heat exchangers.

Topic 4.2. Evaporation and evaporation plants.

Evaporation. Designated and technical methods. Single-shell evaporation plants, methods of their calculation.
Multi-shell evaporators. Basic schemes. Calculation methods.
Distribution of useful temperature difference. Optimal number of housings. Classification of evaporators.

Topic 4.3. Drying and drying plants.

Physico-chemical foundations of drying. Properties of moist gases. I-X diagram.
Classification of drying equipment. Convective dryer. Calculation of material and heat balance.
Calculation of material and heat balance according to the I-X diagram. Variants of drying processes and their analysis.
Drying kinetics. Process periods. Determination of drying duration.
Dryers and their calculation methods.

- Educational materials and resources

4.1. Basic

1. Kornienko Ya.M. Processes and equipment of chemical technology 1: textbook /Ya.M. Kornienko, Yu.Yu. Lukach, I.O. Mikulyonok, V.L. Rakytsky, G.L. Ryabtsev – K.: NTUU “KPI”, 2011 – Part 1 – 300 p.
2. Kornienko Ya.M. Processes and equipment of chemical technology 2: textbook /Ya.M. Kornienko, Yu.Yu. Lukach, I.O. Mikulyonok, V.L. Rakytsky, G.L. Ryabtsev – K.: NTUU “KPI”, 2011 – Part 2 – 416 p.
3. Kasatkin A.H. Basic processes and apparatuses of chemical technology. - M.: Khimiya, 1973. - 752 p.

4. 4.2 Additional

5. Thermal processes and apparatuses of chemical and oil refining industries// Part 1. Yu.Yu. Lukach, I.O. Mikulyonok, G.L. Ryabtsev, M.V. Sezonov. – K.: NMCVO, 2000.-172 p. Part 2. Yu.Yu. Lukach, I.O. Mikulyonok, V.L. Rakytsky, G.L. Ryabtsev. – K.: NMCVO, 2004.-161 p.
6. Investigation of stationary heat conduction through a cylindrical wall / Compiled by: O.G. Zubriy, L.B. Radchenko. – 1994.
7. Research on heat transfer during thermal convection / Compiled by L.B. Radchenko. – 1994.
8. Research on heat transfer during boiling and condensation / Compiled by: S.V. Sidorenko, I.A. Andreev. – 1993.
9. Research on the heat transfer process in a heat exchanger with U-shaped tubes / Incl.

Educational content

- Methodology for mastering the academic discipline (educational component)

5.1 Structure of the credit module

Chapter and topic names	Number of hours				
	Total	including			
		Lectures	Practical (seminar)	Laboratory (computer lab)	CRC
1	2	3	4	5	6

Chapter 1 Transfer phenomena in chemical production processes and devices.					
Topic 1.1 Introduction to the course of processes and apparatus.	2	2		-	-
Topic 1.2. Transfer phenomena in chemical technology.	8	6	-	-	2
Topic 1.3. Fundamentals of similarity theory.	6	4			2
Total under section 1	16	12			4
Chapter 2. Fundamentals of Heat Transfer					
Topic 2.1. Thermal conductivity.	18	4	4	4	6
Topic 2.2. Convective heat transfer.	20	8	4	4	4
Topic 2.3. Heat transfer during a change in the state of aggregation.	12	4	4		4
Topic 2.4. Heat transfer by radiation.	5	2			3
Topic 2.5. Complex heat transfer	11	4	4	-	3
Topic 2.6. Non-stationary thermal conductivity	11	4		4	3
Together under section 2	77	26	16	12	23
Section 3. Heat exchange equipment					
Topic 3.1. Heating and cooling in chemical technology.	26	6	8-	8	4
Topic 3.2 Evaporation and evaporation plants in chemical technology.	22	4	6	8	4
Topic 3.3 Drying and drying plants in chemical technology.	22	4	6	8	4
ICR for sections 1,2,3.	2	2		-	
Calculation work	15	-	-	-	15
Exam preparation	30	-	-	-	30
Together under section 3	117	16	20-	24	57
Together according to section 1,2,3	210	54	36	36	84

5.2. Lectures

No.salary	Title of the lecture topic and list of main questions (list of didactic aids, references to literature and tasks for the SRS)
	Chapter 1 Transfer phenomena in chemical production processes and devices.
1-	Topic 1.1. Introduction to the course of processes and devices.
	The classification and types of chemical and technological processes are given. Literature 1-7.
2-4	Topic 1.2. Transfer phenomena in chemical technology.
	The equations of conservation of mass, energy, equilibrium, driving force and the principles of their solution are analyzed. References 1-7.
5.6	Topic 1.3. Fundamentals of similarity theory.

	Conditions and similarity theorems are given. Criteria, criterion equations and principles of their derivation are analyzed. References 1-7.
	Chapter 2. Fundamentals of Heat Transfer
7.8	Topic 2.1. Thermal conductivity.
	The concepts of thermal energy and types of its transfer, temperature field and temperature gradient are considered. The basic equation of heat conduction is derived and analyzed. The coefficient of heat conduction, conditions of uniqueness and cases of heat transfer under boundary conditions of the first and third kind through a flat and cylindrical wall are considered. Literature 1-7.
9-12	Topic 2.2. Convective heat transfer.
	The heat transfer equation and the physical content of the heat transfer coefficient are analyzed. The physical and mathematical models and ways of its solution are considered. The criteria and criterion equations of thermal similarity and partial cases of convective heat transfer are given. Literature 1-7.
13.14	Topic 2.3. Heat transfer during a change in the state of aggregation.
	Types and physical models of condensation and boiling processes are considered, calculation dependencies for determining heat transfer coefficients and ways of their intensification are analyzed. Literature 1, 2, 3.
15.16	Topic 2.4. Heat transfer by radiation.
	The essence of radiation, basic laws and heat exchange between two bodies and gases are considered. Literature 1-7.
17	Topic 2.5. Complex heat transfer
	Types and physical models of complex heat transfer are considered, calculation dependencies for determining heat transfer coefficients and ways of their intensification are analyzed. Literature 1-7.
18,19	Topic 2.6. Non-stationary thermal conductivity
	The basics and specific cases of solving problems of non-stationary heat conduction are considered. References 1-7.
20-22	Topic 2.7. Heating and cooling in chemical technology.
	The requirements for coolants, their characteristics, basic heating schemes, and the basics of their calculation are considered.
	Typical designs of heat exchangers, methods of design and verification calculations and ways of intensification of the heat transfer process are given. The mutual movement of coolants and the procedure for determining the driving force of heat transfer are analyzed. The basics of calculating heat exchangers are given.
23-24	Topic 2.8. Evaporation and evaporation plants in chemical technology.
	The physical essence of the evaporation process is considered using the example of a single-shell evaporator with a central circulation pipe. Material and heat balances are compiled, the features of determining the useful temperature difference are

	analyzed, and a calculation algorithm is provided. Multi-shell evaporators and their features in co-flow, counter-flow, and parallel feeding are considered. The distribution of the useful temperature difference for different cases and typical device designs are studied. The basics of calculating evaporators are provided. SRS: Provide a classification and compile an album of evaporator designs. Highlight application cases, advantages and disadvantages. Literature 1-7.
25.26	Topic 2.9. Drying and drying plants in chemical technology.
	The physical essence of the drying process and its types are considered. Convective drying and parameters of moist air are studied, analytical and graph-analytical methods for their determination are used. The material and heat balances of drying are compiled. The concept of a theoretical dryer is introduced and drying options are given. Calculation dependencies for determining the air and heat consumption for drying are given. Drying curves, drying periods and an algorithm for determining the drying rate are considered. Dependencies for determining the duration of drying in the first and second periods and the overall dimensions of dryers are given. SRS: Provide a classification and compile an album of dryer designs. Highlight application cases, advantages and disadvantages Literature 1-7.
27	Control module work

5.3. Practical classes

Practical classes are designed to familiarize students with individual topics in more detail and to better assimilate the material taught in lectures.

No.salary	Title of the topic to be presented for the practical session	Number of hours
	Section 1. Transfer phenomena in chemical production processes and devices.	
	Topic 1.3. Fundamentals of similarity theory.	
1	Physical and mathematical models of transfer processes, solution methods and similarity criteria, their properties and physical content are considered. Literature 1-7.	2
	Chapter 2. Fundamentals of Heat Transfer	
	Topic 2.1. Thermal conductivity.	
2.3	.Calculations of the process of thermal conductivity and thermal resistance for single-layer, multi-layer and cylindrical walls.. Literature 1-7.	4
	Topic 2.2. Convective heat transfer.	
4.5	Partial cases of convective heat transfer and an algorithm for calculating heat transfer and heat transfer coefficients are considered. References 1-7.	4
	Topic 2.3. Heat transfer during a change in the state of aggregation.	

6	Features and examples of calculating heat transfer coefficients and heat transfer during boiling and condensation are considered. Literature 1-7.	2
	Topic 2.5. Complex heat transfer	
7.8	Examples of complex heat transfer calculations are considered. References 1-7.	4
	Topic 2.7. Heating and cooling in chemical technology.	
8-12	Heating and cooling schemes, device designs and examples of their calculation are considered. References 1-7.	8
	Topic 2.8. Evaporation and evaporation plants in chemical technology.	
13-15	Schemes, designs and examples of calculation of evaporation plants are considered. References 1-7.	6
	Topic 2.9. Drying and drying plants in chemical technology.	
16-18	Schemes, designs and examples of dryer calculations are considered. References 1-7.	6

<table>
<tr><td>5.4.
2.3</td><td>Research into heat transfer during thermal convection.
Literature 1-7, 17.</td><td>4</td></tr>
<tr><td>4.5</td><td>Thermal conductivity research Laboratory classes.
The main tasks of the laboratory cycle are to gain experience in compiling balance equations of heat exchange processes, as well as analyzing research data and summarizing the results obtained. Systematization and consolidation of knowledge of fundamental equations of mass, energy, momentum transfer and general principles of their solution for specific processes of chemical technology. Systematization and consolidation of knowledge regarding the physicochemical foundations of thermal processes and principles of calculation of relevant apparatuses of chemical technology.
<table>
<tr><td>No.salary</td><td>Name of laboratory work (computer workshop)</td><td>Number of hours</td></tr>
<tr><td>1</td><td>Introductory lesson. Introduction to safety requirements. Formation of groups, subgroups. Introduction to laboratory equipment. Formulation of requirements for the implementation, preparation of reports and defense of laboratory work.</td><td>2</td></tr>
</table>
through a cylindrical wall References 1-7, 14.</td><td>4</td></tr>
<tr><td>6.7</td><td>Research on the designs of heat exchangers and the heat transfer process in a heat exchanger with U-shaped tubes.
Literature 1-7, 18.</td><td>4</td></tr>
<tr><td>8.9</td><td>Research on non-stationary thermal conductivity
Literature 1-7, 15.</td><td>4</td></tr>
<tr><td>10.11</td><td>Research into the designs of evaporators and the process of heat transfer during boiling and condensation.</td><td>4</td></tr>
</table>

	Literature 1-7, 17.	
12.13	Research on dryer designs and dryers with partial recirculation of the drying agent. Literature 1-7, 21. Defense and submission of a laboratory report	4
14.15	Research on a heat exchanger with a ribbed surface References 1-7,19	4
16,17	Protection of design briefs	4
18	Defense and submission of laboratory reports	2

- Student's independent work

The credit module "Processes and equipment of chemical technologies - 2. Thermal processes" provides for the following types of student work: lectures, practical and laboratory classes, one modular test and independent work of the student. The study of the discipline ends with an exam, which is allowed to students who have fully completed the program of the credit module, namely, defended all the tasks that were assigned to lecture, practical and laboratory classes.

The main form of studying the discipline by students is independent work with recommended educational and teaching-methodical literature. The purpose of this work is to acquire theoretical knowledge of the discipline, develop skills and experience in the design of industrial equipment.

The aim of lectures is to generalize and systematize the knowledge acquired by students during independent work.

Practical classes are designed to familiarize students with individual topics in more detail and to better assimilate the material taught in lectures.

Laboratory classes allow students, by completing certain appropriately formulated tasks, to consolidate the theoretical provisions of the credit module and acquire skills and experience in their practical application.

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6.1. Individual tasks

When studying the course, individual tasks are not provided.

6.2. Tests

One modular test is planned.

The main goal of the test is to check the level of mastery of the material being taught, which will simplify the assimilation of the material by students and ensure more complete control by the teacher over the implementation of the curriculum by students.

Indicative questions are included in Appendix B.

- Policy and control

- Academic discipline policy (educational component)

The system of requirements that the teacher places on the student/postgraduate student is indicated:

- *rules for attending classes (both lectures and practical/laboratory);*
- *rules of conduct in classes (activity, preparation of short reports or texts, turning off phones, using communication devices to search for information on the teacher's Google Drive or on the Internet, etc.);*
- *rules for protecting laboratory work;*

- *rules for defending individual assignments;*
- *rules for assigning incentive and penalty points;*
- *deadline and rescheduling policy;*
- *academic integrity policy;*
- *other requirements that do not contradict the legislation of Ukraine and regulatory documents of the University.*

- Types of control and rating system for assessing learning outcomes (RSO)

A student's credit module rating consists of the points he receives for:
1. completion and defense of 10 (at the teacher's choice) tasks.
2. completion and defense of 4 laboratory works and 3 sections of the design outline;
3. writing MCR;
4. answer on the exam.

Rating (weighting) points system and evaluation criteria

<u>1. Work in practical classes</u>

Weighted score - 2. The maximum number of points for all practical classes is:

2 points x 10 = 20 points.

Evaluation criteria:

A score of 2 is awarded for an excellent answer.

A score of 1 is awarded if the answer is sufficient.

A score of 0 is assigned if the answer is unsatisfactory.

<u>2. Laboratory work</u>

Weighted score - 6. The maximum number of points for all laboratory work and design notes is:

6 points x 4 = 24 points.

Evaluation criteria:

- preparation and performance of laboratory work:

A score of 2 is given for excellent work;

A score of 0 is given for unsatisfactory performance.

- quality (protection) of work:

A score of 2 is awarded if the answer is excellent;

A score of 1 is awarded if the answer is sufficient;

A score of 0 is assigned if the answer is unsatisfactory.

- preparation and defense of one section of the design outline:

A score of 2 is awarded if the answer is excellent;

A score of 1 is awarded if the answer is sufficient;

A score of 0 is assigned if the answer is unsatisfactory.

<u>3. Modular control</u>

Weighted score – 16

A score of 16-12 is awarded if at least 95% of the questions are answered;

A score of 11-9 is awarded if 85 to 95% of the questions are answered correctly;

A score of 8-6 is awarded if 75 to 85% of the questions are answered correctly;

A score of 5-2 is given if 60 to 75% of the questions are answered correctly;

A score of 1-0 is given if less than 60% of the questions are answered.

<u>5. Penalty and incentive points for:</u>

- denial of admission to laboratory work due to unsatisfactory entrance control -1 point;
- absence from a laboratory class without a valid reason - 2 points;
- Untimely (later than at the test session) submission of laboratory work or a section of the constructions outline - 1 point.
- untimely (later than at the control session) submission of the apparatus calculation at the practical session - 2 points;
- incentive points: completing tasks to improve didactic materials from the credit module - up to 10 points.

The size of the rating scale RD= 100 points.

The size of the starting scale Rc= Rпр+Rлаб+RМКР =20+24+16=60 points.

The size of the examination scale Re= 40 points.

Conditions for a positive interim certification

To receive a “pass” from the first interim certification (week 8), the student must have at least 8 points (provided that at the beginning of week 8, according to the calendar of control measures, the “ideal” student should receive 17 points).

To receive a "pass" from the second interim certification (week 14), the student must have at least 22 points (provided that at the beginning of week 14, according to the calendar plan of control measures, an "ideal" student should receive 45 points).

Conditions for admission to the exam: passing all practical classes, laboratory work, calculation work, a positive result of the modular test, as well as a starting rating of Rc > 24 points (at least 40% of Rc).

Examination evaluation criteria: the examination ticket contains 4 questions, the maximum number of points for the questions is distributed equally.

Table of criteria for evaluating answers to ticket questions

Response level	Number of points for answering the question			
	Question 1	Question 2	Question 3	Question 4
Distinctive	9-10	9-10	9-10	9-10
Very good	7-8			
Good	5-6	6-8	6-8	6-8
Satisfactory	3-4	3-5	3-5	3-5
Sufficient	1-2	1-2	1-2	1-2
Unsatisfactory	0	0	0	0

Table of correspondence of rating points to grades on the university scale:

Number of points	*Rating*
100-95	Perfectly
94-85	Very good
84-75	Good
74-65	Satisfactorily
64-60	Enough
Less than 60	Unsatisfactorily
Admission conditions not met	Not allowed

- Additional information on the discipline (educational component)

- *a list of questions submitted for semester control (for example, as an appendix to the syllabus);*
- *the possibility of enrolling certificates for completing distance or online courses on the relevant topic;*
- *other information for students/postgraduate students regarding the specifics of mastering the academic discipline.*

The working program of the academic discipline (syllabus):

Compiled by: Associate Professor of the Department of Machines and Apparatuses for Chemical and Oil Refining Industries, Candidate of Technical Sciences, Associate Professor, Shved Mykola Petrovych

Approved by the Department of the IACHR (protocolNo.20 of 12.06.2025)

Approved by the Faculty Methodological Commission (protocolNo.11 of 27.06.2025)

Appendix A

to the working curriculum of the credit module "Processes and equipment of chemical technologies - 1. Thermal processes.

Questions to the ICR

1. What are temperature gradient, isothermal surface and temperature field and what are their properties?

- Write and analyze the heat conduction equations for different types of temperature fields.
- Conditions of uniqueness and their types.
- Derive the equation for the temperature distribution in a flat wall.
- Derive the equation for the temperature field in a cylindrical wall.
- Derive the equation for the temperature distribution in a multilayer wall under first-order boundary conditions.
- Derive and analyze the basic heat transfer equation.
- What factors does the body's emissivity depend on?
- Give the basic laws of thermal radiation.
- How to determine the amount of heat transferred from a hotter body to a colder one.
- Give the mechanism of convective heat transfer.
- Give a system of equations that describes convective heat transfer.
- The essence and basic theorems of the similarity theory method.
- How do you transform differential equations that describe a process into criterion equations? Give a generalized criterion equation.
- Name the main criteria of hydrodynamic and thermal similarity. Indicate their main physical content. Describe the modified similarity criteria.
- Name the main advantages and disadvantages of similarity theory.
- What is the difference between the equations for determining the heat transfer coefficient for forced and free convection?
- What determines the intensity of heat transfer and the ways of its intensification.

- Give an algorithm for calculating the heat transfer coefficient.
- Give the mechanism of condensation and the features of determining the heat transfer coefficient. Name the condensation factors. How does the gas content affect heat transfer?
- List the types of boiling and explain the concept of the critical temperature difference during boiling.
- Derive and analyze the equation for the average temperature difference between coolants in co-flow and counter-flow.
- What are the requirements for coolants?
- What process is called heat transfer?
- What equation determines the relationship between the amount of heat transferred and the size of the heat exchange equipment?
- What is the physical meaning of heat transfer coefficient?
- What process is called heat transfer?
- What parameters characterize heat transfer during natural and forced convection?
- Why are criterion equations of convective heat transfer used in computational practice?
- What criteria of thermal and hydrodynamic similarity are included in the criterion equations of convective heat transfer? What is their physical significance?
- What are the features of heat transfer in the event of a change in the state of aggregation? What criterion is used to take these features into account? What is the physical essence of this criterion?
- What is the relationship between heat transfer coefficient and heat transfer coefficients?
- What quantities make up the total thermal resistance to heat transfer?
- What is the driving force behind heat exchange processes?
- Why is the average driving force used in calculations of heat exchange processes?
- force? How is it defined?
- In what ways can the heat transfer process be intensified?
- What heating methods are used in chemical production?
- What equation is used to determine the flow rate of the coolant for heating?
- In what cases can "hot" steam be used for heating?
- In what cases is heating with flue gases used? What are the disadvantages of heating with flue gases?
- What methods of electric heating are used in chemical production?
- What are the positive qualities and disadvantages of water and air when cooling hot coolants? How to determine the cooling water flow rate in a heat exchanger?
- How are heat exchangers classified?
- What is the structure and operating principle of a single-pass shell-and-tube heat exchanger?
- What intensifies heat transfer in multi-pass shell-and-tube heat exchangers?
- In what cases are temperature compensators used in shell-and-tube heat exchangers?
- When are tube-in-tube heat exchangers used? What are their advantages and disadvantages compared to shell-and-tube heat exchangers?
- How is a spiral heat exchanger constructed? What are its disadvantages?
- In which chemical industries are plate heat exchangers used? What are their positive qualities and disadvantages?
- When are heat exchangers with ribbed heat transfer surfaces used? Give a comparative description of different types of heat exchangers.
- Provide a diagram of the design calculation of heat exchangers. What values should be known when performing design calculations of heat exchangers?
- Why perform hydraulic calculation of heat exchangers?
- What is the optimal calculation of heat exchangers?
- What is the difference between a verification calculation of heat exchangers and a design calculation?
- What is condensation?
- What is the purpose of the condensation process in chemical production?
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- What is the peculiarity of calculating surface capacitors?
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- What is the mechanism for creating a vacuum in vacuum installations using the condensation process?
- What is the purpose of a barometric tube?
- For what purpose is a two-stage barometric condenser used?
- Why calculate the amount of non-condensable gases?
- How is the height of a barometric tube calculated?
- Explain the essence of the evaporation process.
- What solutions are concentrated by evaporation?
- What methods are used to carry out the evaporation process in the chemical industry?
- How does the useful temperature difference differ from the total difference?
- What are the temperature losses in an evaporator unit?
- What does the amount of evaporated water depend on?
- How is the consumption of heating steam during evaporation determined?
- List ways to save heating steam during evaporation.
- For what purpose are conditions created in evaporators for the circulation of the evaporated solution?
- What is the procedure for calculating evaporation plants?
- Why are extra pairs selected?
- What causes the phenomenon of self-evaporation?
- How is the total useful temperature difference of a multi-shell evaporator distributed across the shells?
- How to determine the optimal number of housings for a multi-housing evaporator unit?
- What are the most common evaporator designs in industry?
- What process is called drying?
- What is the driving force behind the drying process?
- Explain the concepts of: relative humidity, moisture content, and enthalpy of moist air.
- Explanation of the principles of constructing a diagram of the first state of moist air.
- List and characterize the types of moisture bonding with the material.
- How is air flow (total and specific) for drying determined?
- From which balance is the specific heat consumption and heating steam consumption for drying determined?
- How is the process of theoretical and real drying structured on the I-x diagram?
- What are the options for the drying process?
- Explain the principles of constructing drying curves and drying rates.
- What factors determine the drying rate in the first and second periods?
- By what criteria are dryers classified?
- Describe the structure and principle of operation of convection dryers.
- Describe the structure of contact dryers.
- Which materials should be dried in convection dryers, and which in contact dryers?
- Describe special types of drying: sublimation, infrared radiation, and in a field of high-frequency currents.
- Name the methods of intensification of drying processes.