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

Department of Chemical Engineering and Oil Refining Industry

EQUIPMENT OF CHEMICAL INDUSTRIES

Working program of the academic discipline (Syllabus)

Level of higher education	***First (undergraduate)***
Branch of knowledge	*17 Electronics and telecommunications*
Specialty	*174 Automation, computer-integrated technologies and robotics*
Educational program	*Technical and software automation tools*
Discipline status	*Selective*
Form of education	*Full-time (day)/distance/mixed*
Year of training, semester	*3rd year, spring semester, LA-21, LA-22, LA-23, LK-p31*
Scope of the discipline	*4 credits (120 hours)*
Semester control/ control measures	*Test*
Lessons schedule	*Lectures - 2 hours (1 pair once every two weeks), practical - 2 hours (1 pair per week)* *https://rozklad.kpi.ua/,https://ecampus.kpi.ua/*
Language of teaching	*Ukrainian*
Information about the Lector / teachers	***Lector:*** *Ph.D. Husarova O.V.* *contact details: phone +380663120701, O.V.Husarova@nas.gov.ua* Practical: *assistant Hryhoriy Serhiyovych Podyman, podiman_g_s@ukr.net*
Placement of the course	https://classroom.google.com

Program of educational discipline

1. Description of the educational discipline, its purpose, subject of study and learning outcomes

An effective automation system cannot be developed without knowing the design and parameters of the automation object. Such problems are solved by this educational discipline, which plays a significant role in the training of bachelors at real industrial facilities.

The study of the discipline contributes to the development of professional thinking and the use of methods and knowledge from this discipline when mastering the professional disciplines of the "Technical and software tools of automation" program.

the purpose *discipline is the formation of the acquirers of the ability to understand the technical and functional characteristics of chemical production facilities and to use the acquired knowledge and skills in solving engineering problems related to the development, design and modernization of equipment chemical industries.*

subject *discipline is the study of structures and basic parameters of regulated equipment processes of chemical production, methods of determining kinetic and dynamic characteristics of equipment, methods of applying theoretical apparatus of heat and mass exchange in solving practical problems.*

Program learning outcomes are:

1) Knowledge and ability to apply the principles of hydrodynamics and heat and mass transfer in the development of automation systems.

2) Knowledge of constructions and principles of operation of chemical production equipment as objects of automation.

3) Ability to calculate and select control valves and devices.

4) The ability to explain the influence of measurement accuracy on product quality and consumption of raw materials and energy.

Required skills:

1) Knowledge of the professional foundations of chemical technology processes and devices.

2) Knowledge of software products: Microsoft Office, AutoCAD, Matlab.

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

The discipline belongs to the cycle of electives and is based on the knowledge of the following disciplines: "Higher mathematics", "Physics", "Engineering and computer graphics", "Processes and devices of chemical technology".

Theoretical knowledge and practical skills acquired during the study of this discipline can be used when mastering the disciplines of the educational program "Technical and software tools of automation".

3. Content of the academic discipline

Chapter 1. Classification of processes and their driving forces.

Topic 1.1. Classification of chemical and technological processes.

Chapter 2. Hydromechanical processes and their hardware implementation.

Topic 2.1. Basics of hydraulics. Hydrostatics and hydrodynamics.

Topic 2.2 Separation of heterogeneous systems.

Topic 2.3 Mixing in liquid media.

Chapter 3. Heat exchange processes and their hardware implementation.

Topic 3.1. Main types of thermal processes and equipment.

Chapter 4. Mass transfer processes and their hardware implementation.

Chapter 5. Mechanical processes and their hardware implementation.

Chapter 6. Equipment for reaction processes

Chapter 7. Combustion processes and their hardware implementation.

Topic 7.1 Furnaces and their basic schemes.

4. Educational materials and resources

Basic literature, which must be used to master the discipline, is worked out independently for preparation for practical classes and in the conditions of distance learning. It is recommended to use additional literature and Internet resources to perform modular tests, prepare reports, presentations, and write essays based on the results of independent work.

Basic literature:

1. Обладнання хімічних виробництв : Конспект лекцій [Електронний ресурс] : навч. посіб. для студ. спеціальності 151 Автоматизація та комп'ютерно-інтегровані технології, освітня програма "Технічні та програмні засоби автоматизації" / КПІ ім. Ігоря Сікорського; уклад.: Швед М.П., Степанюк А.Р., Гусарова О.В., Швед Д.М. – Електронні текстові дані (1 файл: 3,71 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2023. – 181 с. https://ela.kpi.ua/handle/123456789/54632

2. Обладнання хімічних виробництв: Практикум [Електронний ресурс] : навч. посіб. для студ. спеціальності 151 «Автоматизація та комп'ютерно-інтегровані технології», освітня програма "Технічні та програмні засоби автоматизації" / КПІ ім. Ігоря Сікорського; уклад.: Степанюк А.Р., Гусарова О.В. – Електронні текстові дані (1 файл: 2,71 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2023. – 152 с. https://ela.kpi.ua/handle/123456789/54106

3. Федік Л. Ю. Виробничі процеси і обладнання об'єктів автоматизації: навч. посіб. / Л. Ю. Федік, Л. О. Гуменюк, П. О. Гуменюк. – Луцьк: Вежа-Друк, 2020. – 286 с.: іл.

Additional literature:

4. Яцков М.В., Корчик Н.М., Мисіна О.І. Виробничі процеси та обладнання об'єктів автоматизації. Навч. посібник / М.В. Яцков, Н.М. Корчик, О.І. Мисіна - Рівне: НУВГР, 2014. – 389 с.

5. Корнієнко Я.М. Процеси та обладнання хімічної технології 1: підручник / Я.М. Корнієнко, Ю.Ю. Лукач, І.О. Мікульонок, В.Л. Ракицький, Г.Л. Рябцев – К. :НТУУ „КПІ", 2011 – Ч.1 – 300 с.

6. Корнієнко Я.М. Процеси та обладнання хімічної технології 2: підручник / Я.М. Корнієнко, Ю.Ю. Лукач, І.О. Мікульонок, В.Л. Ракицький, Г.Л. Рябцев – К. :НТУУ „КПІ", 2011 – Ч.2 – 416 с.

7. Теплові процеси та апарати хімічних і нафтопереробних виробництв // Ч.1. Ю.Ю. Лукач, І.О. Мікульонок, Г.Л. Рябцев, М.В. Сезонов. – К.: НМЦВО, 2000.-172 с.

Теплові процеси та апарати хімічних і нафтопереробних виробництв // Ч.2. Ю.Ю. Лукач, І.О. Мікульонок, В.Л. Ракицький, Г.Л. Рябцев. – К.: НМЦВО, 2004.- 161 с.

Regulatory documentation:

9. ДСТУ EN 247-2003 Теплообмінники. Термінологія.

10. ДСТУ EN 305-2001 Теплообмінники. Визначання експлуатаційних характеристик теплообмінників та загальна методика випробовування для встановлення експлуатаційних характеристик усіх теплообмінників.

11. ДСТУ EN 1118:2008. Теплообмінники. Охолоджувачі рідини, охолоджувані холодоагентом. Методи випробовування для встановлювання робочих характеристик (EN 1118:1998, IDT).

12. ДСТУ EN 12547:2016 «Центрифуги. Загальні вимоги щодо безпеки» (EN 12547:2014, IDT).

13. ДСТУ Б А.2.4-16:2008 Автоматизація технологічних процесів. Умовні графічні зображення приладів і засобів автоматизації в схемах.

14. Обладнання хімічних виробництв: конспект лекцій / укладач М. П. Юхименко. – Суми : Сумський державний університет, 2015. – 119 с.

5. Educational content
Methods of mastering an educational discipline (educational component)

Information (by sections, topics) about all educational classes (lectures, practical, seminars, MKR, independent work of the students).

5.1 Lecture classes

Lectures are aimed at:

- *provision of modern, comprehensive in-depth knowledge of the discipline;*
- *provision of critical creative work together with the teacher in the process of work;*
- *education of students' professional qualities and development of their independent creative thinking.*

No.	***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 Independent work of the student (IWS))***	***Number hours***
	Chapter 1. Classification of processes and their driving forces.	
	Topic 1.1. Kclassification of chemical and technological processes	
1	***Lecture 1.*** *Introduction to the chemical production equipment course, the main areas of automation.* *The classification of chemical and technological processes is provided. The equations of conservation of mass, energy, balance and driving force are analyzed.*	0.5

	Literature: *1, 3, 4.*	
	Chapter 2. Hydromechanical processes and their hardware implementation	
	Topic 2.1. Basics of hydraulics. Hydrostatics and hydrodynamics	
2	***Lecture 1***. Ideal and real fluids are characterized. The main equation of hydrostatics, flow continuity,*Bernoulli's equation. Modes of fluid movement.*	0.5
	Tasks on IWS: *Cases of practical use of the basic equation of hydrostatics. Hydraulic radius and equivalent diameter.The use ofBernoulli's evolution in technology for determining the speed and flow of matter.* ***literature****: 1, 3, 4-8.*	
3	***Lecture 1.*** *Hydraulic machines.* *Dynamic and volumetric pumps, their classification. Vane pumps, classification, principle of operation. Piston pumps.Automation process moving liquids and gases.* ***Tasks on IWS:*** *To study the constructions, classification, advantages and disadvantages of hydraulic machines.* ***Literature: 1-4.***	1
	Topic 2.2 Separation of heterogeneous systems. ***Topic 2.3 Mixing in liquid media.***	
4	***Lecture 2.*** *Heterogeneous systems and methods of their separation. Basic information about centrifuges. Classification of centrifuges, main designs and principle of operation, advantages and disadvantages. Basic designs and principle of operation of separators. Automation of the process of centrifugation of liquid systems.* *Basic information about mixing in liquid media. Types of mixing devices. Automation of the process of mixing liquids.* ***Tasks on IWS:*** *Hydrocyclones.* ***Literature:*** *3-8, 12*	2
	Chapter 3. Heat exchange processes and their hardware implementation	
	Topic 3.1. Main types of thermal processes and equipment	
5	***Lecture 3.*** *Thermal processes. The main types of thermal processes are given, basic information is provided. Heat exchangers and their designs. Their advantages and disadvantages, the principle of operation. Comparison of heat exchangers. A typical solution for automating the heating process in a shell-and-tube heat exchanger.* ***Tasks on IWS:*** *To study the designs, classification, advantages and disadvantages of heat exchangers.* ***Literature:*** *1-11.*	2
6	***Lecture 4.*** *Evaporation. Basic information. Material and heat balance. Single-body and multi-body evaporation plants. Basic designs and principle of operation of vaporizers. Automation of the evaporation process.* ***Tasks on IWS:*** *Heat transfer when the aggregate state changes (phase transition): boiling, condensation.* ***Literature:*** *1-8.*	2
	Chapter 4. Mass transfer processes and their hardware implementation	
7	***Lecture 5.*** *The main types of mass exchange processes. Drying process.The drying mechanism and types of drying units are given. The characteristics of moist air as a drying agent and the representation of the process on the I-x diagram are given. Automation of the drying process.* ***Tasks on IWS:*** *To study the classification and designs of drying equipment. Highlight use cases, advantages and disadvantages.* ***literature****: 1-8.*	2

8	***Lecture 6.*** *Sorption process. Hardware implementation of absorption and adsorption processes. Extraction process. Hardware implementation of the extraction process. Automation of mass transfer processes.* ***Tasks on IWS:*** *To study the classification and designs of mass transfer equipment. Highlight use cases, advantages and disadvantages.* ***literature****: 3-8.*	2
	Chapter 5. Mechanical processes and their hardware implementation	
9	***Lecture 7.*** *The main types of mechanical processes. Grinding. Basic designs of grinding machines. Automation of mechanical processes. Automation of the process of mixing solid materials. Automation of the grinding process of solid materials. Automation of the solid materials dosing process.* ***Tasks on IWS:*** *To study the classification and designs of crushers. Highlight use cases, advantages and disadvantages.* ***literature****: 3-8.*	2
	Chapter 6. Equipment for reaction processes	
10	***Lecture 8****. Reaction reactors. Apparatus for liquid reactions. Apparatus for heterogeneous reactions.* *Apparatus for carrying out reactions on a solid catalyst.Low pressure reactors. High pressure reactors. Automation of reactors.* ***Tasks on IWS:*** *To study the classification and designs of reactors. Highlight use cases, advantages and disadvantages.* ***literature****: 14.*	*2*
	Chapter 7. Combustion processes and their hardware implementation. ***7.1 Furnaces and their basic schemes***	
11	***Lecture 9****. General scheme of the furnace. Heat engineering processes in furnaces. General classification of furnaces and their main schemes. Mine, shelf, drum, tube and other furnaces. Optimum burning conditions. Regulation of fuel and air consumption.* ***Tasks on IWS:*** *To study the classification and designs of furnaces, their main schemes. Highlight use cases, advantages and disadvantages.* ***literature****: 5-8.*	*2*
	Hours in general	***18***

5.2. Practical training

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

No.	***The name of the topic presented at the practical lesson***	***Number hours***
	Chapter 1. Classification of processes and their driving forces.	
	Chapter 2. Hydromechanical processes and their hardware implementation	
	Topic 2.1. Basics of hydraulics. Hydrostatics and hydrodynamics	
1	*Study of designs of machines for moving liquids and gases. Hydraulic calculation and selection of a centrifugal pump. A typical diagram of pipelines before calculating the pump.* *Literature 1, 2.*	*2*
2	*Movement and compression of gases. Compressor machines, their classification and designs.* ***Test 1 "Pumps and compressors".*** *Literature 1-4.*	*2*

	Topic 2.2 Separation of heterogeneous systems	
3	*Advocacy Basic information about settling tanks. Types of clarifiers. Literature 3, 4.*	*2*
4	*Basic information about filtering heterogeneous systems. Types of filters. Literature 3, 4.*	*2*
5	*Mixing. The main designs of mixers, their advantages and disadvantages.* ***Test 2 "Separation of heterogeneous systems".*** *Literature 3, 4.*	
	Chapter 3. Heat exchange processes and their hardware implementation	
6	*The heating process. Requirements for coolants and heating schemes with water, steam, mineral oils and other high-temperature coolants, electric current and furnace gases are given. Cooling process to normal and low temperatures. References 1-11.*	*2*
7	*Study of designs of heat exchange devices (block (graphite) heat exchanger, mixing condensers, screw heat exchanger, etc.).* ***Test 3 "Heat exchange and heat exchange equipment"*** *Literature 1-8.*	*2*
8	*Crystallization. Basic designs of crystallizers. References 3-8.*	*2*
9	*Evaporation. Vaporizers, their designs, principle of operation, advantages and disadvantages. Literature 1, 2.*	*2*
10	*Repetition of the topic "Heat exchange processes and their hardware implementation".* ***Test 4 "Crystallization and mixing"*** *Literature 1-4.*	*4*
	Chapter 4. Mass transfer processes and their hardware implementation	
11	*Processes of mass exchange. Drying. Dryers. Literature 1, 2.*	*2*
12	*Mass transfer columns. Their designs, principle of operation and use. Literature 5-8.*	*2*
	Chapter 5. Mechanical processes and their hardware implementation	
13	*Methods of separation of solid materials by particle size. Equipment for sorting and classification of solid materials. Literature 5-8.*	*2*
14	*Grinding. Mills Vibromills Feeders* ***Test 5 "Mass exchange and mechanical processes"*** *Literature 5-8.*	*2*
	Chapter 6. Apparatus for carrying out reactions on a solid catalyst. ***Chapter 7. Furnaces and their basic schemes.***	
15	***MCW*** *References 1-14.*	*2*
16	*Work in a team on a project. Preparation of a project/presentation on a group of equipment chosen by the teacher. Drawing up a technological scheme.*	*2*
17	*Work in a team on a project. Preparation of a project/presentation on a group of equipment chosen by the teacher. Drawing up a technological scheme.*	*2*
18	***Protection of abstracts (HCW).*** *References 1-14.*	*2*
	Hours in general	***36***

5.3 Laboratory classes

Laboratory classes are not included in the curriculum.

6. Independent work of the student

The discipline "Chemical Production Equipment" involves the following types of student work: lectures and practical classes, one modular control work, a home control work (abstract), as well as the student's independent work, which makes up 55% of the time of the credit module, including preparation for the assessment. The study of the discipline ends with the preparation of a credit, to which students who have fully completed the program of the credit module are admitted. The main form of studying the discipline by students is independent work with recommended educational and educational and methodological literature.

The purpose of this work*is the acquisition of theoretical knowledge of the discipline, the formation of skills and experience in the design of industrial equipment.*

Lectures are aimed at summarizing and systematizing 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. Tests are provided for practical classes to check the assimilation of the material.

The purpose of homework*is the development of the ability to apply the acquired knowledge to solve practical and theoretical tasks of modern production, gaining experience in performing reporting documentation.*

6.1 Individual tasks

When studying the course, students perform one homework test, the purpose of which is to study equipment designs. Individual tasks are issued according to the topic determined by the teacher.

The result of the work is drawn up in the form of a report, which includes the formulation of the purpose of the work, a description of the design features of the device. The volume of the report is 10-15 A4 pages.

6.2 Control works

One modular control work is planned.

The main purpose of the control work is to check the level of mastery of the taught material, which will make it easier for students to learn the material and provide more complete control by the teacher over the students' implementation of the curriculum.

7. Policy and control

7.1 Policy of academic discipline (educational component)

The student must be present at all lectures, practical classes, except for confirmed good reasons.

The protection of practical and individual tasks is carried out personally according to the established deadlines, taking into account incentive and penalty points

Students have the right to challenge the points for the assignment, but must be reasoned, explaining which criterion they disagree with according to the evaluation letter and/or comments.

The detailed criteria for evaluating students' learning outcomes are defined in the regulation on evaluating learning outcomes of the discipline.

7.2 University policy

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, tests, exams.

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

Students should 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

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		
	Believe me	Acad. hours	audio hour	Lectures	Practical	IWS	MCW	HCW (abstract)	Semester control
2	4	120	54	18	36	66	1	1	test

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

1) *performance of tests and tasks in practical classes;*
2) *defense of the essay;*
3) *team work on the project;*
4) *writing MCW;*
5) *the answer to the test.*

System of rating (weighted) points and evaluation criteria

1. Work in practical classes

Weight score - 5.

Evaluation criteria:

- *a score of 5 is awarded under the condition of an excellent answer.*
- *point 4 is awarded on the condition of a sufficient answer.*
- *a score of 3 is awarded subject to a satisfactory answer.*
- *a score of 0 is given if the answer is unsatisfactory.*

The maximum number of points for all practical classes is equal to: 5 points x 14 = 70 points.

2. Modular control

Weight score is 10.

- "excellent" - 9-10 points;
- "good" - 7-8 points;
- "satisfactory" - 5-6 points;
- "unsatisfactory" - 0 points.

3. Abstract (*home control work* **- HCW).**

The weight score is 20.

Evaluation criteria of the Abstract (home control work):

- *a score of 18-20 is given if all sections of the work are covered in full, or some minor inaccuracies are admitted;*
- *a score of 14-16 is awarded if certain inaccuracies are admitted in the work;*
- *a score of 10-13 is given if the topic of the work is not clearly covered, mistakes are made in wording, terms and definitions;*
- *a score of 0 is assigned if the work is performed unsatisfactory: the presence of significant errors or the absence of separate sections, the abstract is not counted.*

4. Penalty and incentive points for:

*- **penalty points:** untimely (later than at the practical session) passing the test or section of the synopsis of structures - minus 2 points.*

- untimely (later than at the 16-18 practical session) submission of the home control work - minus 2 points;

- untimely (later than a week) submission of home control work, MCW - minus 5 points;

*- **incentive points**: performance of tasks to improve didactic materials from the credit module - up to 10 points.*

The size of the rating scale

RD = Rpr+Rmcr+ Ralb=70+10+20 = 100 points

Conditions of positive intermediate attestation

To receive "passed" from the first intermediate certification (week 8), a student must have at least 20 points (provided that at the beginning of week 8, according to the calendar plan of control measures, the "ideal" student must receive 40 points).

In order to receive "credited" from the second intermediate certification (week 14), a student must have at least 35 points (provided that at the beginning of week 14, according to the calendar of control activities, the "ideal" student must receive 70 points).

For 18 weeks of training, based on the results of practical work, the completion of modular control work, the defense of an essay, the maximum number of points a student can score is 100 points.

Conditions for admission to credit:

Enrollment of all practical classes, an essay, a positive result of the modular control work, as well as a starting rating Rs > 40 points.

***To receive credit from the credit module "automatically"** you need to have a rating of at least 60 points, and all types of work are also included.*

***Students who at the end of the semester have a rating of less than 60 points,** as well as those who want to increase their score in the system of rating points, perform a credit test.*

***Credit evaluation criteria:** the ticket contains 4 questions, the maximum number of points for each question is distributed equally.*

Table of criteria for evaluating answers to ticket questions

Response rate	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	7-8	7-8	7-8
Good	5-6	5-6	5-6	5-6
Satisfactory	3-4	3-4	3-4	3-4
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:

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)

During their studies, students acquire new knowledge, skills and abilities, mainly during specific lectures and practical classes under the leadership of the department's leading NPPs.

Quite often, during their studies, students, in order to receive incentive points, are involved in providing assistance in the development of educational and methodological documentation (publication of manuals, licensing, development of methodological documentation, etc.). At the same time, the nature of such assistance must strictly correspond to the profile of the discipline and in terms of duration should not interfere with the implementation of the student's study plan.

Working program of the academic discipline (syllabus):

Compiled by Ph.D, Olena Husarova

Approved by the Department of Chemical Engineering and Oil Refining Industry (protocol No. 20 dated June 20, 2024)

Agreed by the Methodical commission of the faculty[1] (protocol No. 11 dated June 28, 2024)

[1] Methodical council of the university – for general university disciplines.