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

Machines and devices of chemical and oil refining industries

Transfer processes in solid environments

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	*Normative*
Form of education	*daytime*
Year of training, semester	*2nd year, spring semester*
Scope of the discipline	*5 credits*
Semester control/ control measures	*exam, MKR, RR*
Lessons schedule	*http://rozklad.kpi.ua/Schedules/ScheduleGroupSelection.aspx*
Language of teaching	*Ukrainian*
Information about head of the course / teachers	*Lecturer/Practical/Laboratory: associate professor of the department, candidate of technical sciences, associate professor A.R. Stepaniuk, <arstepaniuk@gmail.com>*
Placement of the course	https://ci.kpi.ua/uk/syllabuses-bac-disciplines/#place

Program of 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 in 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:

- *Physics*
- *Chemistry*
- *Higher mathematics*

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

- *Chemical technology processes and equipment*
- *Pre-diploma practice*
- *Diploma design*

2. Content of the academic discipline

Chapter 1. Transfer phenomena and the principle of driving force in chemical technology.

Topic 1. Introduction. The purpose and objectives of the course. Transfer phenomena and the principle of driving force in chemical technology. Determination of the main dimensions of the device.

Chapter 2. Hydrostatics

Topic 2.1. Introduction. Derivation and analysis of the differential equation of fluid statics. Euler's equation. Analysis of the system of equations.

Topic 2.2. Derivation of the main equation of hydrostatics. Cases of practical use of the basic equation of hydrostatics. The principle of operation of connected vessels.

Topic 2.3. Hydrostatic machines

Chapter 3. Hydrodynamics

Topic 3.1. Basic characteristics of a moving fluid. Hydraulic radius and equivalent diameter. Modes of fluid movement. Flow continuity (continuity) equation. Differential equation of fluid motion. Euler's equation for an ideal fluid.

Topic 3.2. Differential equations of motion of a real fluid. Navier-Stokes equation

Topic 3.3. Derivation and analysis of the Bernoulli equation

Chapter 4. Hydraulic supports.

Topic 4.1. Boundary layer. Hydraulic supports. Modes of fluid movement. Cavitation. Head loss during laminar fluid flow. Head losses during turbulent fluid movement. Local hydraulic supports. Calculation of simple pipelines. A simple pipeline of constant cross section. Friction pressure losses (road hydraulic resistance). Local supports. Fluid consumption at a fixed (stationary) flow.

Topic 4.2. Poiseuille's equation. Relationship between maximum and average speed. Determination of the optimal pipeline diameter. Pipelines with pump supply of liquids. Hydraulic shock. Change in the throughput of pipelines during their operation

Chapter 5. Hydraulic machines.

Topic 5.1. Vane pumps. Piston pumps. Indicator diagram of piston pumps. Energy balance in pumps.

3. Educational materials and resources

Basic

1. *Processes and equipment of chemical technologies - 1. Basic principles of the theory of heat and mass transfer: study guide [Electronic resource]: education. manual for students specialty 133 "Industrial mechanical engineering", specialization "Engineering, equipment and technologies of chemical and oil refining industries" / KPI named after Igor Sikorskyi; comp.: A.R. Stepaniuk, S.V. Gulienko - Electronic text data (1 file: 3.57 MB). – Kyiv: KPI named after Igor Sikorskyi, 2018. – 160 p. Access from the screen:http://login.kpi.ua*
2. *Processes and equipment of chemical technologies - 1. Basic principles of the theory of heat and mass transfer: laboratory workshop [Electronic resource]: teaching. manual for students specialty 133 "Industrial mechanical engineering", specialization "Engineering, equipment and technologies of chemical and oil refining industries" / KPI named after Igor Sikorskyi; comp.: A.R. Stepaniuk, S.V. Gulienko - Electronic text data (1 file: 2.59 MB). – Kyiv: KPI named after Igor Sikorskyi, 2018. – 69 p. Access from the screen:http://login.kpi.ua*
3. *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.*
4. *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.*

ducational 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 global trends in the development of science in the field of processes and technology of primary gas and oil processing;*
- *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, observing structural and logical connections, explaining all the 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
	Chapter 1. Transfer phenomena and the principle of driving force in chemical technology.	
1	Introduction. The purpose and objectives of the course. Transfer phenomena and the principle of driving force in chemical technology are analyzed. An analysis of the methods of determining the main dimensions of the apparatus is carried out	2
	Literature 1-5.	
	Chapter 2. Hydrostatics	
2	Derivation and analysis of the differential equation of fluid statics is carried out. The Euler equation is derived and analyzed. Analysis of the system of equations is performed.	2
	Literature 1-5.	
3	The main equation of hydrostatics is derived. Cases of practical use of the basic equation of hydrostatics are analyzed. The principle of operation of connected vessels is analyzed. Hydrostatic machines, their principle of action and design are analyzed.	2
	Literature 1-5.	
	Chapter 3. Hydrodynamics	
4	The main characteristics of the moving fluid are analyzed. The hydraulic radius and equivalent diameter are analyzed. Fluid movement modes are analyzed. The equation of continuity (continuity) of the flow is derived.	2
	Literature 1-5.	
5	The equation of continuity (continuity) of the flow is derived.	2
	Literature 1-5.	
6	The differential equation of fluid motion is derived. The Euler equation and analysis for an ideal fluid are derived.	2
	Literature 1-5.	
7	The differential equations of motion of a real fluid are analyzed. The Navier-Stokes equation is derived and analyzed	2
	Literature 1-5.	
8	The Bernoulli equation is derived and analyzed	2
	Literature 1-5.	
	Chapter 4. Hydraulic supports.	
9	The hydrodynamic boundary layer is analyzed. Hydraulic supports are analyzed. Fluid movement modes are analyzed. The phenomenon of cavitation is analyzed.	2
	Literature 1-5.	
10	Head losses during laminar fluid flow are analyzed. Pressure losses during turbulent fluid movement are analyzed.	2
	Literature 1-5.	
11	Local hydraulic supports are analyzed. An analysis of the hydraulic calculation of simple pipelines is given. A simple pipeline of constant cross-section is analyzed. Frictional pressure losses (road hydraulic resistance) are analyzed. Local supports are analyzed	2
	Literature 1-5.	
12	The flow of liquid at a fixed (stationary) flow is analyzed. The derivation of the equation and Poiseuille analysis are carried out. The relationship between maximum and average speed is analyzed. The determination of the optimal diameter of the pipeline is analyzed. Pipelines with pumped liquid supply are analyzed. Hydraulic shock is analyzed. The change in pipeline capacity during their operation is analyzed	2
	Literature 1-5.	
	Chapter 5. Hydraulic machines.	
13	Dynamic fans, the method of their selection are analyzed.	2

	Literature 1-5.	
14	*The pressure characteristics of dynamic pumps are analyzed.*	*2*
	Literature 1-5.	
	SRS: Album of designs of blade fans	
	Literature 1-5.	
15	*Displacement pumps, the method of their selection are analyzed.*	*2*
	Literature 1-5.	
16	*The pressure characteristics of volumetric pumps are analyzed.*	*2*
	Literature 1-5.	
	SRS: Album of constructions of volumetric pumps	
	Literature 1-5.	
17	*The indicator diagram of volumetric pumps and the energy balance in the pumps are analyzed.*	
	Literature 1-5.	
18	*MKR*	*2*
	Literature 1-5.	

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:

- *to help applicants deepen their theoretical knowledge in the field of transfer processes in solid environments;*
- *promote the training of applicants in the methodology of determining the properties of environments in the processes of transfer in continuous environments;*
- *form criteria for evaluating the effectiveness of transfer processes in solid environments.*

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. Hydrostatics	
	Topic 2.1. Introduction. Derivation and analysis of the differential equation of fluid statics. Euler's equation. Analysis of the system of equations.	
	Literature 1-4.	
	SRS: Repeat topic 2.1.	
	Literature 1-4.	
1	*Problems using the basic equation of hydrostatics.*	*2*
	Literature 1-4.	
	SRS: Repeat topic 2.1	
	Literature 1-4.	
	Topic 2.2. Derivation of the main equation of hydrostatics. Cases of practical use of the basic equation of hydrostatics. The principle of operation of connected vessels.	
2	*Problems using the force of fluid pressure on a flat or curved wall. Problems using Archimedes' law.*	*2*

	Literature 1-4.	
	SRS: Repeat topic 2.2.	
	Literature 1-4.	
	Chapter 3. Hydrodynamics	
	Topic 3.4. Derivation and analysis of the Bernoulli equation	
3	*Problems using the Bernoulli equation.*	*2*
	Literature 1-4.	
	SRS: Repeat topic 3.4.	
	Literature 1-4.	
	Chapter 4. Hydraulic supports.	
	Topic 4.1. Hydrodynamic boundary layer. Hydraulic supports. Modes of fluid movement. Cavitation. Head loss in laminar fluid flow. Head losses during turbulent fluid movement.	
4	*Problems on determining hydraulic resistance.*	*2*
	Literature 1-4.	
	SRS: Repeat topic 4.1.	
	Literature 1-4.	
	Topic 4.2. Local hydraulic supports. Hydraulic calculation of simple pipelines. A simple pipeline of constant cross section. Friction pressure losses (road hydraulic resistance). Local supports. Fluid consumption at a fixed (stationary) flow.	
5	*Problems on determining hydraulic resistance.*	*2*
	Literature 1-4.	
	SRS: Repeat topic 4.2.	
	Literature 1-4.	
	Topic 4.3. Poiseuille's equation. Relationship between maximum and average speed. Determination of the optimal pipeline diameter. Pipelines with pump supply of liquids. Hydraulic shock. Change in the throughput of pipelines during their operation	
6	*Problems on the calculation of pipelines.*	*2*
	Literature 1-4.	
	SRS: Repeat topic 4.3.	
	Literature 1-4.	
	Chapter 5. Hydraulic machines.	
	Topic 5.1. Dynamic pumps.	
7	*Pump selection problems*	*2*
	Literature 1-4.	
	SRS: Repeat topic 5.1.	
	Literature 1-4.	
	Topic 5.2. Volumetric pumps.	
8	*Tasks on the selection of fans.*	
	Literature 1-4.	*2*
	SRS: Repeat topic 5.2.	
	Literature 1-4.	

9	*Problems on indicator diagrams of volumetric pumps and energy balance in pumps.*	*2*
	Repeat sections 1-5	
	Literature 1-4.	

Laboratory classes

- *The main purpose of the cycle of laboratory works:*
- *gaining experience in conducting studies of kinetic regularities of the main processes of chemical technology and the corresponding equipment;*
- *systematization and consolidation of knowledge of the fundamental equations of transfer of mass, energy, quantity of motion and general principles of their solution for specific processes;*
- *systematization and consolidation of knowledge about the physical and chemical foundations of thermal processes and the principles of calculation of the corresponding devices;*
- *systematization and consolidation of knowledge about the constructions and principles of operation of heat exchange devices and the peculiarities of their calculation;*
- *summarized results.*

No s/p	***The name of the topic of the laboratory session and the list of main questions (list of didactic support, references to the literature and tasks on the SRS)***	***Number hours***
	Chapter 3. Hydrodynamics	
	Chapter 4. Hydraulic supports.	
	Topic 4.1. Hydrodynamic boundary layer. Hydraulic supports. Modes of fluid movement. Cavitation. Head loss in laminar fluid flow. Head losses during turbulent fluid movement.	
1-2	*Determination of the mode of movement of the liquid.*	*4*
	Literature 5-7.	
	SRS: Repeat topic 4.1.	
	Literature 1-4.	
	Topic 4.2. Local hydraulic supports. Hydraulic calculation of simple pipelines. A simple pipeline of constant cross section. Friction pressure losses (road hydraulic resistance). Local supports. Fluid consumption at a fixed (stationary) flow.	
3	*Determination of hydraulic resistance of the cyclone.*	*2*
	Literature 5-7.	
	SRS: Repeat topic 4.2.	
	Literature 1-4.	
4-5	*Determination of the hydraulic resistance of the graphite heat exchanger.*	*4*
	Literature 5-7.	
	SRS: Repeat topic 4.2.	
	Literature 1-4.	
6-7	*Determination of coefficients of hydraulic resistance of partitions and nozzles.*	*4*
	Literature 5-7.	
	SRS: Repeat topic 4.2.	
	Literature 1-4.	
	Chapter 5. Hydraulic machines.	
	Topic 5.1. Dynamic pumps.	
8	*Determination of the pump head depending on the productivity.*	*2*

	Literature 5-7.	
	SRS: Repeat topic 5.1.	
	Literature 1-4.	
	Topic 5.2. Volumetric pumps.	
9	*Determination of the pump fan depending on the performance.*	*2*
	Literature 5-7.	
	SRS: Repeat topic 5.2.	
	Literature 1-4.	

Calculation work

One calculation work is planned.

The main goal of the calculation work is to improve the level of assimilation of the taught material, which will facilitate the assimilation of the material by students and ensure more complete control by the teacher over the implementation of the curriculum by students.

Tasks and implementation methods are set out in the methodical instructions posted on the websitehttp://ci.kpi.ua/uk/.

5. 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 the independent work of the applicants is to deepen worldview and scientific knowledge in the directions specified in the lectures, by searching for the necessary information, forming perseverance and creative search in the formation of working hypotheses for the intensification of transfer processes.

Calculation work:*One calculation work is planned.*

The main goal of the calculation work is to improve the level of assimilation of the taught material, which will facilitate the assimilation of the material by students and ensure more complete control by the teacher over the implementation of the curriculum by students.

Tasks and implementation methods are set out in the methodical instructions posted on the websitehttp://ci.kpi.ua/uk/.

Policy and control

6. 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 miss them without valid reasons, not to interfere with the teacher conducting classes and not to be distracted by actions not related 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

7. 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	Semester control
4	5	150	36	18	18	78	1	1	exam

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:

Performing tasks in practical classes.

A weighted point for questions in lectures is 1 point

The weighted score for practical classes is 2 points each;

The weighted score for laboratory classes is 2 points each;

The weighted score for independent work is 7 points;

The weighted score for MKR is 4 points

The weighted score for RR is 7 points

Exam 20 points

Criteria for evaluating the performance of a practical task

Completeness and signs of task completion	***Points***
The task is fully completed	*2*
Minor defects according to point 1	*1.5*
Untimely completion of the task	*1.0*
Untimely completion of the task, deficiencies under clause 1	*1.0*
Poor performance of the task	*0.5*

Failure to complete the task	*0*

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

R =17 1 +9 2+ 9 2 +1 9+ 1 7+1 7+1 25 = 100 points

According to the results of the educational work in the first 7 weeks, the "ideal achiever" should score 40 points. At the first attestation (8th week), the applicant receives "passed" 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*

8. Additional information on the discipline (educational component)

An approximate list of questions submitted for semester control

The ticket consists of three questions

- *Analyze the derivation and analysis of the differential equation of fluid statics. Euler's equation.*
- *Analyzederivation of the main equation of hydrostatics.*
- *Analyze cases of practical use of the basic equation of hydrostatics.*
- *Analyze the concept of hydrostatic machines*
- *Analyze the main characteristics of a moving fluid.*
- *Analyze the continuity (continuity) equation of the flow.*
- *Analyze the differential equation of fluid motion. Euler's equation for an ideal fluid.*
- *Analyze the differential equations of motion of a real fluid. Navier-Stokes equation.*
- *Analyze the derivation and analysis of Bernoulli's equation.*
- *Analyze the hydrodynamic boundary layer.*
- *Analyze the hydraulic radius and equivalent diameter.*
- *Analyze pressure losses in laminar fluid flow.*

- *Analyze head losses during turbulent fluid movement.*
- *Analyze local hydraulic supports .*
- *Analyze the hydraulic calculation of simple pipelines.*
- *Analyze the flow rate of the fluid at a fixed (stationary) flow. Poiseuille's equation*
- *Analyze the determination of the optimal diameter of the pipeline.*
- *Analyze the concept of cavitation.*
- *Analyze the concept of hydraulic shock.*
- *Dynamic pumps. Draw a diagram and analyze the design of vortex pumps.*
- *Dynamic pumps. Draw a diagram and analyze the construction of centrifugal pumps.*
- *Dynamic pumps. Draw a diagram and analyze the construction of axial pumps.*
- *Dynamic pumps. Draw a diagram and analyze the design of jet pumps.*
- *Dynamic pumps. Draw a diagram and analyze the design of scoop pumps.*
- *Dynamic pumps. Draw a diagram and analyze the design of screw pumps.*
- *Volumetric pumps. Draw a diagram and analyze the design of screw pumps.*
- *Volumetric pumps. Draw a diagram and analyze the design of membrane pumps.*
- *Volumetric pumps. Draw a diagram and analyze the design of piston pumps.*
- *Volumetric pumps. Draw a diagram and analyze the design of gear pumps.*
- *Volumetric pumps. Draw a diagram and analyze the construction of hose (peristaltic) pumps.*

Working program of the academic discipline (syllabus):
Compiled by an associate professor of the Department of the National Academy of Sciences of the Russian Academy of Sciences, candidate. technical of Sciences, associate professor Andrii Stepaniuk

Approved by the Department of the Academy of Medical Sciences (protocol No. 19 dated May 17, 2023)

Agreed by the Methodical Commission of the faculty (protocol No. 10 dated 05/26/2023)