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

Department of Machines and Apparatus of Chemical and Oil Refining Production

"Processes and apparatus of chemical production 2. Mechanical, hydromechanical and mass transfer processes"

The syllabus of the credit module

Details of the discipline	
Level of higher education	**First (bachelor's) degree**
Field of expertise	16 - Chemical and bioengineering
Specialty.	161 - Chemical technology and engineering
Education programs	"Electrochemical Technologies of Inorganic and Organic Materials, Chemical Technologies of Inorganic Substances and Water Treatment, Chemical Technologies of Organic Substances; Chemical Technologies of Cosmetics and Food Additives
Status of the educational component	regulatory
Scope of the discipline	165 hours/ 5.5 ECTS credits
Year of study, semester	3rd year, spring semester
Form of study	full-time (daytime)
Class schedule	1 lecture and 1 laboratory lesson per week
Semester control / control measures	examination
Language of instruction	English
Information about the course leader / teachers	phD, Associate Professor, Seminsky Oleksandr Olehovych, forstd@ukr.net , @mahnv_kpi
Placement of the course	http://ci.kpi.ua

Program of the discipline

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

The credit module "Processes and Apparatus of Chemical Production 2. - Mechanical, Hydromechanical and Mass Transfer Processes" is taught jointly to higher education applicants (hereinafter referred to as applicants) specified in the details of this educational program at the Faculty of Chemical Technology.

The purpose of the ***credit module*** is to master basic knowledge of mechanical, hydromechanical and mass transfer processes of chemical production and their implementation in industrial equipment.

According to the higher education standard, the credit module forms the following ***competencies***:

- knowledge and understanding of the subject area and understanding of professional activities in terms of mechanical, hydromechanical and mass transfer processes and equipment of chemical production;

- the ability to apply knowledge of the physical and chemical characteristics of mechanical, hydromechanical and mass transfer processes, equipment design and application, determination of operating parameters and technical decision-making in practical situations;
- the ability to apply standard analytical methods, quantitative methods of mathematics, physics, engineering sciences, as well as computer software tools to effectively solve chemical engineering problems;
- ability to use modern materials, technologies and apparatus designs in chemical engineering.

These competencies are disclosed in the ***program learning outcomes***, which include:

- ability to correctly use in professional activities the terminology and basic concepts of chemistry, chemical technologies, processes and equipment for the production of chemicals and materials based on them;
- knowledge and understanding of the mechanisms and kinetics of mechanical, hydromechanical and mass transfer processes and the ability to effectively use them in the design and improvement of technological processes and devices of the chemical industry;
- the ability to use modern computing equipment, specialized software and information technology to solve complex problems and practical problems in the field of chemical engineering, in particular, to calculate mechanical, hydromechanical and mass transfer processes of chemical production and related equipment;
- the ability to use knowledge of mechanical, hydromechanical and mass transfer processes and relevant equipment to ensure the safety of personnel and the environment during professional activities in the field of chemical engineering.

2. Prerequisites and post-requisites of the discipline (place in the structural and logical scheme of study in the relevant educational program)

The credit module is taught on the basis of the disciplines "Physics" and "General Chemical Technology", as well as the credit module "Processes and Apparatus of Chemical Production 1. - Thermal Processes", complements the disciplines "Physical Chemistry" and "Chemical Kinetics and Surface Phenomena", provides educational components "Undergraduate Practice" and "Diploma Design".

3. Content of the discipline

Topic 1: Mechanical processes.

Topic 2. Hydromechanical processes.

Topic 3. Mass transfer processes.

4. Training materials and resources

Basic literature:

1. Processes and equipment of chemical technology / Y.M. Kornienko, Y.Y. Lukach, I.O. Mikulonok, B.L. Rakytsky, G.L. Ryabtsev. K.: NTUU "KPI", 2011. - [P. 1. - 300 p.; P. 2.-416 p.].

2. Vragov A.P. Mass exchange processes and equipment of chemical and gas and oil refining industries: a textbook for students of higher educational institutions / A.P. Vragov. - Sumy: University book, 2016. - 284 c.

3. Mechanical, hydromechanical and mass transfer processes: laboratory workshop [Electronic resource]: a textbook for students majoring in 161 "Chemical Technology and Engineering", specialization "Electrochemical Technologies of Inorganic and Organic Materials" / Igor Sikorsky Kyiv Polytechnic Institute. Korniienko Y.M., Stepaniuk A.R., Gulienko S.V. - Electronic text data (1 file: 4.81 MB) - Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2020. 217 p.

4. Processes and apparatus of chemical technologies : in 5 parts : [textbook for students of higher educational institutions, studying in the direction. "Chemical Technology and Engineering" and

"Engineering Mechanics"] / Ministry of Education and Science of Ukraine, Lviv Polytechnic National University ; edited by Y.M. Khanyk. - Lviv: Lviv Polytechnic, 2010.

5. Processes and apparatus of chemical technology : textbook : in 2 parts : translated from Russian / L.L. Tovarzhnyansky [and others] ; edited by L.L. Tovarzhnyansky ; Ministry of Education and Science of Ukraine, National Technical University "Kharkiv Polytechnic University". - Kharkiv : NTU "KHPI", 2007.

Additional reading:

1. Perry's Chemical Engineers' Handbook / Editor-in-Chief D.W. Green. - McGraw-Hill Education, 2019. - 2274 p.

2. Field R. Chemical Engineering: Introductory Aspects / R. Field. - Macmillan Publishers Limited, 1988. - 180 p.

3. Cheremisinoff N. Handbook of Chemical Process Equipment / N. Cheremisinoff, Butterworth-Heinemann, 2000. - 535 p.

4. Processes and apparatus of chemical production. Section: Equipment for grinding and classification of materials [Electronic resource] : methodical instructions for course projects for students in the field of training 6.051301 "Chemical Technology", specialties "Chemical technologies of refractory non-metallic and silicate materials", "Chemical technologies of processing of polymeric and composite materials" / NTUU "KPI" ; comp. O.M. Tymonin, I.V. Kovalenko, V.V. Malynovskyi - Electronic text data (1 file: 27.4 MB) - Kyiv : NTUU "KPI", 2015. 63 p.

Educational content

5. Methods of mastering the discipline (educational component)

Calendar and thematic plan

Week	*The content of the training work*	*SRS (93 hours according to the curriculum)*
Topic 1: Mechanical processes.		
1	**Lecture.** Introductory part. The essence and application of mechanical processes. Fundamentals of grinding.	Study the topic of the class. Work with the recommended literature. Study of the design of grinding equipment.
	Laboratory lesson. Introductory lesson. Familiarization with safety rules. Familiarization with laboratory equipment.	Receive and familiarize yourself with the recommended literature.
2	**Lecture 2**: Evaluation of grinding results. Representation of dispersed formulations and approaches to their analysis. Kinetics of grinding.	Study the topic of the class. Work with the recommended literature. Study of the design of grinding equipment.
	Laboratory class. Laboratory work 1: studying the operation of a jaw crusher (experimental part).	Preparation for laboratory work. Preparation of the protocol.
3	**Lecture.** Energy hypotheses of grinding and estimation of energy consumption for the process. Grinding cycles.	Study the topic of the class. Work with the recommended literature. Study of the design of grinding equipment.

Week	*The content of the training work*	*SRS (93 hours according to the curriculum)*
	Laboratory class. Laboratory work 1: studying the operation of a jaw crusher (analytical part).	Performing calculations, summarizing the results, and drawing conclusions based on the results of the work.
4	**Lecture.** Fundamentals of mechanical separation of dispersed materials. Screening and its types. Material balance, efficiency and kinetics of the process.	Study the topic of the class. Work with the recommended literature. Study of the design of screens and classifiers.
	Laboratory class. Laboratory work 2: study of the kinetics of deposition (experimental part).	Preparation for laboratory work. Preparation of the protocol.
Topic 2. Hydromechanical processes.		
5	**Lecture.** Introduction to hydromechanical processes. Basic binary systems and their features. Hydrodynamic similarity. Basic and derived criteria of hydrodynamic similarity.	Study the topic of the class. Work with the recommended literature.
	Laboratory class. Laboratory work 2: study of deposition kinetics (analytical part).	Performing calculations, summarizing the results, and drawing conclusions based on the results of the work.
6	**Lecture.** Separation of heterogeneous systems under the influence of gravity: physical foundations of the process, derivation of the deposition equation in differential and invariant forms, analysis of process parameters and determination of its speed, approaches to equipment selection.	Study the topic of the class. Work with the recommended literature. Study of the design of the deposition equipment.
	Laboratory class. Laboratory work 3: Investigation of fluidized bed hydrodynamics (experimental part).	Preparation for laboratory work. Preparation of the protocol.
7	**Lecture.** Differential pressure separation: basic information about filtration, filtration rate and kinetics, process equation and its special cases.	Working out the topic of the lesson. Work with the recommended literature. Study of filtering equipment designs.
	Laboratory class. Laboratory work 3: Study of fluidized bed hydrodynamics (analytical part).	Performing calculations, summarizing the results, and drawing conclusions based on the results of the work.
8	**Lecture.** Separation under the action of centrifugal force-1. Separation in cyclones: features of the process and design of cyclones, estimation of separation efficiency, equation of separation under the action of centrifugal force and its application.	Study the topic of the class. Work with the recommended literature. Study of cyclone structures.

Week	*The content of the training work*	*SRS (93 hours according to the curriculum)*
	Laboratory class. Laboratory work 4. Study of the operation of a filter centrifuge (experimental part).	Preparation for laboratory work. Preparation of the protocol.
9	**Lecture.** Separation under the action of centrifugal force-2. Separation in centrifuges: features of the process and design of centrifuges and their application, determination of settling time, productivity and energy consumption for the process.	Study the topic of the class. Work with the recommended literature. Study of centrifuge designs.
	Laboratory class. Laboratory work 4. Study of the operation of a filter centrifuge (analytical part).	Performing calculations, summarizing the results, and drawing conclusions based on the results of the work.
10	**Lecture.** Fundamentals of fluidization: the essence of the process and its features, types of fluidized layers and fluidization modes, information on practical application, fluidization curves and process analysis, calculation features.	Working out the topic of the lesson. Work with the recommended literature. Study of the design of fluidization apparatus and gas distribution devices.
	Laboratory class. Laboratory work 5. Study of mixing of liquids (experimental part).	Preparation for laboratory work. Preparation of the protocol.
11	**Lecture.** Mixing: the essence of the process, methods of mixing; mechanical mixing (hydrodynamics, design features and operation of high-speed and low-speed devices, their application); mixing equations and energy consumption for the process.	Working out the topic of the lesson. Work with the recommended literature. Study of the design of mixing apparatus and mechanical mixing devices.
	Laboratory class. Laboratory work 5. Study of mixing of liquids (analytical part).	Performing calculations, summarizing the results, and drawing conclusions based on the results of the work.
12	**Lecture.** Special methods of mixing: bubbling, circulation, using siatical mixers; assessment of the intensity and efficiency of mixing.	Study the topic of the class. Work with the recommended literature. Study of the design of equipment for bubbling and circulating mixing, static mixers.
	Laboratory class. Laboratory work 6. Study of the hydrodynamics of a casing string (experimental part).	Preparation for laboratory work. Preparation of the protocol.
Topic 3. Mass transfer processes.		

Week	*The content of the training work*	*SRS (93 hours according to the curriculum)*
13	**Lecture.** Fundamentals of mass transfer: the most common mass transfer processes and their features; physical essence of mass transfer; equilibrium in mass transfer; basic laws; material balance of mass transfer, equation of the working line and its special cases; basic equation of mass transfer.	Study the topic of the class. Work with the recommended literature.
	Laboratory class. Laboratory work 6. Study of the hydrodynamics of the packed column (analytical part).	Performing calculations, summarizing the results, and drawing conclusions based on the results of the work.
14	**Lecture.** Mechanisms of mass transfer: molecular, turbulent, convective diffusion; Fick's first law, thermodiffusion; analogy of hydrodynamic, thermal and mass transfer processes; Fick's second law; mass transfer and Shchukarev's law; mass transfer at the interface.	Study the topic of the class. Work with the recommended literature.
	Laboratory activity. Laboratory work 7. Investigation of mass transfer during desorption in a packed column (experimental part).	Preparation for laboratory work. Preparation of the protocol.
15	**Lecture.** The driving force of mass transfer. Determination of the average driving force for straight and curved equilibrium lines; determination of the mass transfer coefficient. Basic equations and relations necessary for calculating process parameters.	Study the topic of the class. Work with the recommended literature.
	Laboratory activity. Laboratory work 7. Study of mass transfer during desorption in a packed column (analytical part).	Performing calculations, summarizing the results, and drawing conclusions based on the results of the work.
16	**Lecture.** Similarity of transfer processes. Basic criteria of similarity in mass transfer and their physical essence.	Study the topic of the class. Work with the recommended literature.
	Laboratory class. Laboratory work 8. Study of a plate distillation column (experimental part).	Preparation for laboratory work. Preparation of the protocol.
17	**Lecture.** Basic information about absorption and desorption. Methods of conducting. Kinetics and features of the processes.	Study the topic of the class. Work with the recommended literature. Study of absorber designs and their components.
	Laboratory class. Laboratory work 8. Study of a plate distillation column (analytical part).	Performing calculations, summarizing the results, and drawing conclusions based on the results of the work.

Week	*The content of the training work*	*SRS (93 hours according to the curriculum)*
18	**Lecture.** Basic information about rectification and distillation. Features of the processes. Physical meaning of the concepts of the number of transfer units and the height of the transfer unit, approaches to their definition, explanation of application.	Study the topic of the class. Work with the recommended literature. Study of the design of distillation apparatus, distillation columns and their components.
	Laboratory class. Module control work. Submission of a report on laboratory work.	Preparation for the module test. Prepare a report on laboratory work.
Notes. Laboratory work is performed by students in subgroups. The recommended number of students in a subgroup is four. The procedure for performing laboratory work is determined by the teacher who leads the laboratory workshop, individually for each of the subgroups.		

6. Independent work of the student

The types of independent work are listed in clause 5, according to the academic weeks and scheduled classes.

Policy and control

7. Policy of the academic discipline (educational component)

A system of requirements for students:

- **rules for attending classes** - attendance at all types of classes (lectures, laboratory classes) is mandatory both in classrooms and in distance learning. In the latter case, classes are held in Zoom conferences, and attendance is considered to be when a student joins the Zoom conference online using the links provided by the teachers and works in class;
- **rules of behavior in the classroom** - do not interfere with other students' listening to lectures or working in laboratory classes by unnecessary activities or conversations (including by phone). In the classroom and during distance learning, follow safety rules;
- **rules for crediting laboratory classes and awarding points for their completion** - the teacher evaluates the student's work during the class, the quality and timeliness of the presentation of the results of the task;
- **rules for awarding reward and penalty points:**

1) incentive points are provided in the form of the possibility of crediting the educational component based on the results of work in the semester ("automatic") in the presence of high performance and defense of tasks, which are considered: attendance at least 15 lectures, timely writing of the module test, practice and defense of laboratory work; the "automatic" grade is calculated by the formula: 2*(semester rating - 10); the possibility of receiving an automatic grade and its value is announced at the pre-exam consultation, after which, before the exam, the student must inform about his or her agreement with the result of the assessment or refuse the offer and proceed to the exam;

2) 2 penalty points are awarded for absence from class without a valid reason or for late completion of laboratory assignments;

- **policy of deadlines and retakes**:

1) practicing, defending, and evaluating the results of all assignments takes place exclusively during classroom sessions;

2) re-taking any task to improve the grade is not allowed;

3) absence from a class without a valid reason cannot be grounds for making up the class;

4) retakes of the exam are carried out according to the schedule of retakes of the results of semester control established at the university level within the time limits determined by the teacher and communicated to students when the exam results are announced;

- **policy on academic integrity** - students are obliged to comply with the provisions of the Code of Honor and the requirements of academic integrity during the educational process; detection of academic dishonesty in the performance of an assignment leads to the non-accreditation of such an assignment with the need to repeat it with a change in the initial data and leads to the deprivation of the right to receive an automatic grade; repeated detection of academic dishonesty in the work of the same student leads to his/her exclusion from the exam.

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

Current control: assessment of students' work in laboratory classes (up to 6 points for each completed and defended laboratory work, maximum for all laboratory classes 6x8=48 points), assessment of the module test (maximum 12 points).

Calendar control: is carried out twice a semester on weeks 7-8 and 14-15 as a monitoring of the current state of fulfillment of SilaBus requirements - a student receives "certified" during the first and second calendar control if his or her current rating is at least 0.5 of the maximum number of points possible at the time of the control.

Semester control is conducted in the form of an exam consisting of two parts: written and oral. The written part involves answering three questions (two theoretical and one practical). The questions are formulated in tickets. The oral part consists of a questionnaire on the course topics related to the questions in the ticket. Theoretical questions are worth a maximum of 12 points, and practical questions are worth a maximum of 16 points.

Conditions of admission to semester control:

- admission to the exam is possible only in case of successful completion and defense of all laboratory works, writing a module test and attending at least 10 lectures;
- students who received a total rating score of < 20 during the semester are not allowed to take the exam;
- individual semester ratings of students and the availability of admission to the exam are announced at the pre-exam consultation.

Table of correspondence between rating points and grades on the university scale:

Number of points	*Assessment.*
100-95	Excellent
94-85	Very good
84-75	Okay.
74-65	Satisfactory
64-60	Enough
Less than 60	Unsatisfactory
The conditions for admission are not met	Not allowed

9. Additional information on the discipline (educational component)

Retakes are conducted according to a "soft" scheme (with the points gained during the semester). In this case, 10 penalty points are awarded for each retake.

Work program of the discipline (syllabus):

Compiled by Oleksandr Seminsky, Associate Professor of the Department of MAHNV, Candidate of Technical Sciences, Associate Professor.

Approved at the meeting of the Department of Machines and Apparatus of Chemical and Oil Refining Production (Protocole No. 20 of June 20, 2024).

Approved by the Methodological Commission of the Faculty of Engineering and Chemistry (Protocole No. 11 of June 28, 2024).