Національний техн
«КИЇВСЬКИЙ ПО

Department of machines and devices of chemical and oil refining industries

EQUIPMENT FOR CLEANING TECHNOLOGICAL LIQUIDS

Working program of the academic discipline (Syllabus)

Details of the academic discipline	
Level of higher education	***First (undergraduate)***
Branch of knowledge	*10 Natural sciences*
Specialty	*101 Ecology*
Educational program	*Ecological safety*
Discipline status	*Selective*
Form of education	*daytime*
Year of training, semester	*3rd year, autumn semester*
Scope of the discipline	*4 ECTS credits*
Semester control/ control measures	*Score, MKR,*
Lessons schedule	
Language of teaching	*Ukrainian*
Information about the course leader / teachers	Lecturer:*Ph.D., Assoc., SerhiyValeriyovych Gulienko,sergiiguliienko@gmail.com, +38504488173* Practical:not provided for in the curriculum Laboratory:*Ph.D., Assoc., SerhiyValeriyovych Gulienko,sergiiguliienko@gmail.com, +38504488173*
Placement of the course	

Program of educational discipline

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

In chemical technology and related industries, such as biotechnological, food and pharmaceutical, fluids play a key role at all stages of production. They can act as raw materials, such as water, crude oil, raw milk, vegetable oils, extracts of plant materials, etc. Also, liquid solvents and reagents such as alkalis, acids, alcohols and ketones can be used at various stages. In addition, commercial products such as fuel and lubricants, paint products, detergents, beverages and medicines are produced in liquid form, and liquid effluents are among the most dangerous environmental pollutants. Liquid components used as raw materials, solvents or reagents may contain impurities and contaminants that prevent their use in the process without prior preparation. Likewise, the product obtained after reaction or other equipment may contain residual raw materials or by-products that must be removed. A particularly important task is the treatment of liquid effluents. Therefore, in the training of environmental safety specialists, knowledge of the equipment used to solve these problematic industrial problems is important. For this reason, for students studying in the specialty 101 Ecology, the Environmental Safety educational program, an optional educational component "Equipment for cleaning process fluids" is offered for study. which is used to solve these problematic industrial problems. For this reason, for students studying in the specialty 101 Ecology, the Environmental Safety educational program, an optional educational component "Equipment for cleaning process fluids" is offered for study. which is used to solve these problematic industrial problems. For this reason, for students studying in the specialty 101 Ecology, the

Environmental Safety educational program, an optional educational component "Equipment for cleaning process fluids" isofferedforstudy.

Taking into account the properties of liquids, as well as the types of impurities and pollution, a wide variety of technological processes can be used for cleaning. In particular, hydromechanical processes such as sedimentation, filtration, centrifugation and separation in hydrocyclones are effective for removing suspended solids. Also, for more effective cleaning from such systems, reactive methods such as coagulation, flocculation and flotation are used. Mass transfer processes are effective for separating solutions, in particular, distillation, rectification, extraction, adsorption, and ion exchange are used for this purpose. In addition, membrane processes are characterized by high efficiency, in particular, reverse osmosis, nanofiltration, ultrafiltration, microfiltration, electrodialysis, membranedistillationandpervaporation.

The educational component "Equipment for the cleaning of process fluids" provides for the study of equipment for the cleaning of liquid systems according to the above classification. The regularities of the separation processes and the features of the designs of the devices for their implementation are also considered.

The subject of the educational component "Equipment for the purification of technological liquids" is the regularities of liquid media purification processes and the design of equipmentfortheirimplementation.

The purpose of the educational component "Equipment for the purification of technological liquids" is to form a set of knowledge:

- methods of wastewater treatment from soluble and insoluble substances;

- absorption methods of cleaning spent liquids;

- adsorption and membrane methods of water purification.

In accordance with the goal, the preparation of a bachelor's degree in this specialty of studying this educational component ensures the strengthening of the competencesformedbystudents:

- using regulatory and experimental documents

- with data on water pollution, assess its condition and do

- conclusions on the prevention of ecologically negative economic consequences

- human activity;

- competently use water purification technologies from solubleandinsolublesubstances;

- competently use existing equipment anddesignnewones

2. Pre-requisitesandpost-requisitesofthediscipline (placeinthestructuralandlogicalschemeoftrainingaccordingtotherelevanteducationalprogram)

The educational component "Equipment for cleaning process fluids" is optional.

Requirements for starting studies include basic knowledge acquired during the first three courses of training, in particular, knowledge of mathematics, physics, and chemistry.

The study of the discipline will be useful for diploma design, as well as when learning the material of a number of disciplines in the following semesters of bachelor's training

3. Content of the academic discipline

Chapter 1. Liquids and their properties

Topic 1.1. Basic process fluids.

Water and water resources. Oil and oil products. Industrial solvents. Other process fluids

Topic 1.2. Properties of liquids

Physical properties of liquids. Types of pollutants. Liquidqualityrequirements.

Chapter 2. Hydromechanical equipment for water purification

Topic 2.1 Equipment for cleaning in the gravity field

Sedimentation kinetics in the gravitational field. Structures of sedimentation tanks. Material balance of settling tanks.

Topic 2.2 Equipment for cleaning in the field of centrifugal forces

Hydrocyclones. Basicdesignsofhydrocyclones. Factorsaffectingtheefficiencyofhydrocyclones. Materialbalanceofcentrifuges. Classificationofcentrifuges. Centrifugesofsedimentationtype. Centrifugesoffiltrationtype. Designsofcentrifuges

Topic 2.3 Filtration

Kinetics of the filtration process. Basic filtering equation. Designs of filters

Chapter 3. Purification of liquidsbyreagentmethods.

Coagulation. Flocculation. Flotation.

Chapter 4. Mass exchange equipment for cleaning liquids

Topic 4.1 Distillation and rectification

Simple distillation. Fractional distillation. Distillation with dephlegmation. Distillation in a stream of water vapor. Molecular distillation. Periodic rectification. Continuous rectification. Analysis of the work of rectification devices. Peculiarities of plate rectification columns. Features of packed rectification columns. Extractive and azeotropic rectification.

Topic 4.2 Extraction.

Equilibrium during extraction. Choice of extractant. Kinetics of extraction. Technological schemes of liquid extraction. Constructions of extractors

Topic 4.2 Adsorption

Specificity of adsorption of aqueous solutions. Basics of the theory of equilibrium during adsorption. Fundamentals of kinetics and dynamics of adsorption. Designs of adsorbers.

Topic 4.3 Ion exchange

Ion exchange materials and their general characteristics. Theoretical foundations of ion exchange. Designs of ion exchange devices.

Chapter 5. Membrane processes

Topic 5.1 General characteristics of membrane processes

Peculiarities of membrane processes. The role and place of membrane processes. Classification of membrane processes.

Topic 5.1 Baromembraneprocesses

Osmosis. Reverse osmosis. Nanofiltration. Ultrafiltration. Microfiltration. Apparatusforbaromembraneprocesses

Topic 5.2. Other membrane processes used for water treatment

Electrodialysis. Dialysis. Pervaporation. Membranedistillation

Topic 5.3 Operation of membrane equipment.

Concentration polarization. Contamination of the membrane surface. Regeneration of membranes.

4. Educational materials and resources

Basic literature:

1. *Modeling of membrane separation processes [Electronic resource]: study guide for students of specialty 133 "Industrial mechanical engineering", specialization "Engineering, computer modeling and equipment design of chemical and oil refining industries" / KPI named after Igor Sikorskyi; structure. S. V. Gulienko. – Electronic text data (1 file: 3.25 MB). – Kyiv: KPI named after Igor Sikorskyi, 2017. – 166 p. – Titlefromthescreen.*
2. *Modeling of processes of membrane separation: workshop on the educational discipline [Electronic resource]: training. manual for students specialty 133 "Industry of mechanical engineering", specialization "Engineering, computer modeling and equipment design of chemical and oil refining industries" / KPI named after Igor Sikorskyi; comp.: S.V. Gulienko. – Electronic text data (1 file: 2.27 MB). – Kyiv: KPI named after Igor Sikorskyi, 2018. – 104 p.*
3. *Kornienko Y.M. Processes and equipment of chemical technology [Text]: tutorial. / Y.M. Kornienko, Yu.Yu. Lukach, I.O. Mikulonok et al.. - K.: NTUU "KPI", 2011. - Part 2. - 416 p.*
4. *Zapolsky A.K., Mishkova-Klimenko N.A., Astrelin I.M., Brik M.T., Gvozdyak P.I., Knyazkova T.V. Physico-chemicalbasicsofwastewatertreatmenttechnology: Textbook. - K.: Libra, 2000. - 552 p.*

***Additional literature**:*

5. *Study of the process of reverse osmosis. Methodological guidelines for conducting scientific research work of students from the credit module "Modeling of membrane separation processes" [Electronic resource]: / NTUU "KPI"; structure. S.V. Gulienko– Kyiv: KPI named after Igor Sikorskyi, 2017. – 14 p.*
6. *Processes and equipment of chemical technologies: Hydromechanical and mechanical processes: Laboratory workshop [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.: Y.M. Kornienko, A.R. Stepaniuk, S.V. Gulienko, S.S. Heyday - Electronic text data (1 file: 4.80 MB). – Kyiv: KPI named after Igor Sikorskyi, 2020. – 151 p.*
7. *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.*
8.
9. *Gulienko S. V. Theprocessofregenerationofrolledmembranemodules: diss. ... candidatetechnicalSciences: 05.17.08 – processesandequipmentofchemicaltechnology / SerhiyValeriyovychGulienko. - Kyiv, 2016. - 214 p.*
10. *Huliienko SV Korniienko YM, Gatilov KO (2020). Moderntrendsinthemathematicalsimulationofpressure-drivenmembraneprocesses. JournalofEngineeringSciences, Vol. 7(1), pp. F1–F21, doi: 10.21272/jes.2020.7(1).f1*
11. *Huliienko S., Leshchenko O. (2019). Influenceofoperatingpressureonconcentrationpolarizationlayerresistanceinreverseosmosis. Ukrainianfoodjournal. Vol. 8., Is. 1, pp. 119-132.*
12. *https://www.sciencedirect.com/journal/advanced-membranes*
13. *https://www.sciencedirect.com/journal/journal-of-membrane-science*
14. *https://www.sciencedirect.com/journal/desalination*
15. *https://www.sciencedirect.com/journal/journal-of-membrane-science-letters*
16. *https://www.mdpi.com/journal/membranes*

17. http://www.msrjournal.com/
18. https://www.sciencedirect.com/journal/membrane-technology
19. https://www.sciencedirect.com/journal/separation-and-purification-technology
20. https://www.youtube.com/watch?v=qaUQE8OkEjo&list=PL86konoyyLTZDlHM_daQFLJYq0fMhY7sy

(Educational content

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

Lecture classes

Lectures are aimed at:

- *provision of modern, integral, interdependent knowledge in the discipline "Fundamentals of membrane technology", the level of which is determined by the target setting for each specific topic;*
- *ensuring creative work of students together with the teacher during the lecture;*
- *education of students' professional and business qualities and development of theirindependentcreativethinking;*
- *forming the necessary interest in students and providing direction for independent work;*
- *definition at the current level of scientific development in the field of membrane technology;*
- *reflection of the methodical processing of the material (highlighting of the main provisions, conclusions, recommendations, their wording is clear and adequate);*
- *the use of visual materials for demonstration, combining them, if possible, with the demonstration of research results;*
- *teaching research materials in a clear and high-quality language with observance of structural and logical connections, clarification of all newly introducedtermsandconcepts;*
- *accessibility for perception by this audience.*

No. z/p	*The name of the topic of the lecture and the list of main questions (list of didactic tools, references to the literature and tasks on the SRS)*	*Hour*
1	*Lecture 1. Basic process fluids. Water and water resources. Oil and oil products. Industrial solvents. Other process fluids* *Literature [3, 4]* *Tasks for SRS: Sources of technological fluids*	*2*
2	*Lecture 2. Physical properties of liquids. Types of pollutants. Liquidqualityrequirements.* *Literature [3, 4]* *Task for SRS: Dependence of physical properties of liquids on temperature, pressure and composition*	*2*
3	*Lecture 3. Kinetics of sedimentation in the field of gravity. Structures of sedimentation tanks. Material balance of settling tanks.* *Literature [3, 4]* *Tasks for the SRS: The latestconstructionsofclarifiers*	*2*
4	*Lecture 4. Hydrocyclones. Basic designs of hydrocyclones. Factors affecting theefficiencyofhydrocyclones.* *Literature [3, 4]* *Tasks for the SRS: The newestdesignsofhydrocyclones*	*2*
5	*Lecture 5. Material balance of centrifuges. Classification of centrifuges. Centrifuges of sedimentation type. Centrifuges of filtration type. Designsofcentrifuges* *Literature [3]* *Tasks for SRS: Newest designs of filters*	*2*
6	*Lecture 6. Kinetics of the filtration process. Basic filtering equation. Designs of*	*2*

	filters *Literature [3, 4]* *Tasks for SRS: The latest designs of industrial filters*	
7	*Lecture 7. Coagulation. Flocculation. Flotation. Basics of processes. Designs of devices for their implementation.* *Literature [3, 4]* *Tasks for SRS: The latest designs of devices for coagulation, flocculation and flotation*	*2*
8	*Lecture 8. Simple distillation. Fractional distillation. Distillation with dephlegmation. Distillation in a stream of water vapor. Molecular distillation.* *Literature [3, 4]* *Tasks for the SRS: The latest designs of distillation apparatuses*	*2*
9	*Lecture 9. Periodic rectification. Continuous rectification. Analysis of the work of rectification devices.* *Literature [3, 4]*	*2*
10	*Lecture 10. Peculiarities of plate rectification columns. Features of packed rectification columns. Extractive and azeotropic rectification.* *Literature [3, 4]* *Tasks for SRS: Latest designs of distillation columns*	*2*
11	*Lecture 11. Equilibrium during extraction. Choice of extractant. Kinetics of extraction. Technological schemes of liquid extraction. Constructions of extractors* *Literature [3, 4]* *Tasks for SRS: Newest designs of extractors*	*2*
12	*Lecture 12. Specificity of adsorption of aqueous solutions. Basics of the theory of equilibrium during adsorption. Fundamentals of kinetics and dynamics of adsorption. Designs of adsorbers.* *Literature [3, 4]* *Tasks for SRS: The newest designs of adsorbers*	*2*
13	*Lecture 13. Ion exchange materials and their general characteristics. Theoretical foundations of ion exchange. Designs of ion exchange devices.* *Literature [3, 4]* *Tasks for SRS: The latest designs of ion exchange devices*	*2*
14	*Lecture 14. Peculiarities of membrane processes. The role and place of membrane processes. Classification of membrane processes.* *Literature [1-4]*	*2*
15	*Lecture 15. Osmosis. Reverse osmosis. Nanofiltration.* *Literature [1-4]* *Tasks for the SRS: The latest designs of reverse osmosisandnanofiltrationdevices*	*2*
16	*Lecture 16.Ultrafiltration. Microfiltration. Apparatusforbaromembraneprocesses* *Literature [1-4]* *Tasks for the SRS: The latest designs of devices forultrafiltrationandmicrofiltration*	*2*
17	*Lecture 17. Electrodialysis. Dialysis. Pervaporation. Membranedistillation* *Literature [3, 4]* *Tasks for SRS: The latest designs of devices for diffusion, thermalandelectromembraneprocesses*	*2*
18	*Lecture 18. Concentration polarization. Contamination of the membrane*	*2*

	surface. Regenerationofmembranes. *Literature [4]* *Tasks for SRS: Newest methods of membrane regeneration*	
	In total	***36***

Laboratory classes

The main tasks of the cycle of laboratory classes (computer workshops):

- *help students systematize, consolidate and deepen knowledge of a theoretical nature;*
- *to teach students methods of solving practical tasks, to promote the mastery of skills and abilities to perform measurements, calculations, graphic and other types of tasks;*
- *teach how to work with scientific and reference literature, technical documentation and diagrams;*
- *to form the ability to learn and work independently.*

No. z/p	***The name of the topic of the laboratory session and the list of main questions (a list of didactic support, references to the literature and tasks on the SRS)***	***Hour***
1	*Study of fluid flow regimes** *Literature [6-7]*	*4*
2	*Study of the kinetics of the deposition process** *Literature [6]*	*4*
3	*Study of the operation of a filtration centrifuge** *Literature [6]*	*4*
4	*Study of the process of mixing liquids** *Literature [6]*	*4*
5	*Study of masstransferduringdesorption** *Literature [6]*	*4*
6	*Study of the operation of the distillation column** *Literature [6]*	*4*
7	*Study of reverse osmosis process in flow mode** *Literature [5]*	*4*
8	*Study of hydraulic resistance of membrane modules* *Literature [7]*	*4*
9	*Modular control work. Protection of construction albums*	*2*
10	*Test*	*2*
	Together	*36*

** Note: independent work during the performance of all laboratory work is the processing of experimental data and the formulation of conclusions based on the results of the work.*

6. Independent work of student

Independent work takes 40% of the time of studying the educational component, including preparation for the assessment, modular control work and preparation of construction albums. The main task of students' independent work is to acquire knowledge from the course that was not included in the list of lecture questions by personally searching for information, forming an active interest in a creative approach to educational work. In the process of independent work within the framework of the educational component, the student must learn to analyze modern thermodynamic methods used in chemical engineering.

No. z/p	The name of the topic submitted for independent processing	Number of hours of SRS
1	Preparation for lectures	10
2	Preparation for laboratory work	16
3	Execution of construction albums: - hydromechanical equipment (structures of settling tanks, filters, hydrocyclones, etc. - from 10 structures) - mass transfer equipment (structures of rectification columns, extraction devices, adsorbers, etc. - from 5 structures) - membrane equipment (design devices for reverse osmosis, nanofiltration, electrofiltration, etc.)	10
5	Execution of calculation work	6
6	Preparation for the test	6
	Hours in general	48

A special form of independent work of students is the execution of design albums. In the album, the design of each device should contain its principle, a description of the principle of operation, advantages and disadvantages of the design, and the scope of its application. The approximate volume of the description of one design is one full page of A4 format. At least 50% of the designs in the album must be supplemented with the latest designs (from patent or scientific literature)

Policy and control

7. Policy of academic discipline (educational component)

Rules of attending classes and behavior in classes

Attending classes is a mandatory component of the assessment. Students are obliged to take an active part in the educational process, not to be late for classes and not to miss them without a good reason, not to interfere with the teacher conducting classes, not to be distracted by actions unrelated to the educational process. When solving problems in practical classes, students can use any sources of information and means of calculations. All tasks are performed individually.

Rules for the protection of individual tasks

The curriculum does not provide for individual tasks

Rules for assigning incentive and penalty points

- *incentive points can be awarded by the teacher exclusively for the performance of creative works in the discipline or additional completion of online specialized courses with the receipt of the appropriate certificate:*

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 the event of arrears from the academic discipline or any force majeure circumstances, students should contact the teacher through available (provided by the teacher) communication channels to resolve problematic issues and agree on an algorithm of actions for practice.

Policy of academic integrity

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism includes the absence of references for the use of printed and electronic materials, quotes, opinions of other authors. Inadmissible tips and write-offs during writing tests, conducting classes; passing the exam for another graduate

student; copying materials protected by the copyright system without the permission of the author of the work.
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 opinions of others, formulate objections in the correct form, constructively supportfeedbackduringclasses.
Standards of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute". More details:https://kpi.ua/code

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

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

Semester	Training time		Distribution of study hours				Control measures		
	Credits	Acad. hours	Lectures	Practical	Lab. do	SRS	MKR	RR.	Semester control
5	4	120	36	-	36	48	1	-	test

The student's rating in the discipline consists of the points he receives for: performance of 8 laboratory works, preparation and protection of an album of structures and MKR.
Semester control is credit.

System of rating (weighted) points and evaluation criteria

The system of rating points and evaluation criteria:

Performance and protection of laboratory work.

The weighted score is 6. The maximum number of points for laboratory classes is 8·6=48.

Implementation and protection of the design album.

Weight score 12.The maximum number of points for construction albums is 3·12=36.

Modular control work.

Weight score 16

Credit is issued based on the results of work in the semester.

A student who received at least 60 points in the semester can take part in credit work to get a higher point. In this case, the points obtained by him on the control work with the addition of 50% of the points obtained in the semester are final.

The credit control work (if necessary) is evaluated out of 70 points. The control task consists of two theoretical tasks.

Each task is evaluated out of 35 points according to the following criteria:

- *excellent performance of the task, fluency in defense material - 32-34 points.*
- *good level of performance, correct answers to questions when defending the task - 25-30 points.*

- *a sufficient level of task performance, thepresenceofminorinaccuraciesinanswers - 20-22 points.*
- *poor quality of work, ignorance of theoretical material - 0 points.*

The condition of the first attestation is obtaining at least 20 points and completing 50% of practical work (at the time of attestation). The condition for the second attestation is to obtain at least 36 points and complete 75% of practical work (at the time of attestation).

The sum of the points received by the student is transferred to the examination grade according to the table:

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

9. Additional information on the discipline (educational component)

Recommended contents of construction albums:

Construction album No. 1 Hydromechanical equipment

- *Settling tank of periodic action*
- *A sedimentation tank with inclined partitionsofsemi-periodicaction*
- *Continuity clarifier with comb stirrer*
- *Multi-tiered clarifier of continuous action*
- *Sand filter*
- *Nutch filter*
- *Bag filter*
- *Leaf filter*
- *Filter press*
- *Cartridge filter press*
- *Belt vacuum filter*
- *Drum vacuum filter*
- *Disk vacuum filter*
- *Carousel vacuum filter*
- *Cylindroconichydrocyclone*
- *Cylindricalhydrocyclone*
- *Turbohydrocyclone*
- *Sedimentationcentrifugeofperiodicactionwithmanualdischargeofsediment*
- *Sedimentationcentrifugeofperiodicactionwithmanualdischargeofsediment*
- *Screw sedimentation centrifugeofcontinuousaction*
- *Drumseparator*
- *Tubular centrifuge*
- *Three-column centrifuge*
- *Filter centrifuge of continuous action with pulsating sediment discharge*
- *The apparatus with a propeller stirrer and a framestirrer*
- *Apparatus with an anchor stirrer*
- *Apparatus with a paddle stirrer*
- *Apparatus with a turbine stirrer*
- *Apparatuswithbubblingmixing*

Design album #2 Mass transfer equipment

- *Apparatus for simple distillation*
- *Installation for fractional distillation*
- *Installation for distillation with dephlegmation*
- *Installation for distillation with steam*
- *Apparatus for molecular distillation*
- *Installation for periodic rectification*
- *Rectification unit of continuous action*
- *Installation for extractive rectification*
- *Installation for azeotropic rectification*
- *Rectification columnwithsieveplates*
- *Rectification columnwithcapplates*
- *Rectification column with valve plates*
- *Rectification packing column*
- *Hollow extractor with heavy phase dispersion*
- *Hollow extractor with light phase dispersion*
- *Attachment extractor*
- *Plate extractor*
- *Rotary disk extractor*
- *Centrifugal extractor*
- *Vertical pressure adsorber*
- *Pressureless adsorber*
- *Adsorber with a moving layer of adsorbent*
- *Adsorber with a pseudo-fluidizedlayer*
- *Adsorber with stirrer*
- *Ion exchange device with internal regeneration*
- *Ion exchange device with remote regeneration*

Design album #2 Mass transfer equipment

- *Roll membrane apparatus*
- *Flat-framemembranedevice*
- *Tubular membrane device*
- *Capillarymembraneapparatus*
- *Poronistofolokonymembraneapparatus*
- *Ceramic membrane device*
- *Electrodialysis apparatus*

The construction album of each student in the group should contain a unique set of devices. In the case of finding a complete match with a previously protected album of designs, the album in question is returned to the author for revision.

Working program of theacademicdiscipline (syllabus):

Foldedassociateprofessor MAHNV, Ph.D., Assoc. Serhii GULIENKO

ApprovedbytheMAHNV Department (protocolNo. 19 dated 17.05.2023)

Agreedbythemethodicalcommitteeofthefaculty (protocolNo. 10 dated 05/26/2023)