

RESEARCH AND ENGINEERING OF PACKAGING EQUIPMENT

Educational component work program (Syllabus)

Educational component details

Level of higher education	<i>Second (Master's)</i>
Branch of knowledge	<i>G - Engineering, manufacturing and construction</i>
Specialty	<i>G9 «Applied Mechanics»</i>
Educational program	<i>Educational and Professional Program Engineering of packaging products, processes and equipment</i>
Status of the educational component	<i>Mandatory</i>
Form of study	<i>full-time / day</i>
Year of preparation, semester	<i>1 course, autumn semester</i>
The scope of the educational component	<i>5(150)</i>
Semester control/control measures	<i>Exam</i>
Class schedule	
Language of instruction	<i>Ukrainian</i>
Information about the course leader/teachers	Lecturer: https://cpsm.kpi.ua/karvatskij-anton-yanovich.html Practical: https://cpsm.kpi.ua/karvatskij-anton-yanovich.html Laboratory: –
Course placement	<i>Link to a remote resource Google classroom, https://cpsm.kpi.ua/navchannya/sylabusy/sylabusy-2025-roku.html</i>

Educational component program

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

The term "Engineering" comes from the English word "engineering", which means "to build, design, arrange, undertake, invent, invent". Engineering is defined as a set of intellectual activities that have as their ultimate goal the best (optimal) results from capital investments or other expenses associated with the implementation of projects for various purposes through the most rational selection and effective use of material, labor, technological and financial resources in their unity and interconnection, as well as methods of organization and management, based on advanced scientific and technical achievements and taking into account specific conditions and projects.

The current level of development of science and technology requires the training of future specialists with in-depth knowledge in the field of engineering, which in the broad sense of the term includes: drawing up technical tasks; conducting research; drawing up project proposals and feasibility studies for the construction of industrial and other facilities; conducting engineering and search works; developing technical projects and working drawings for the construction of new and reconstruction of existing industrial and other facilities; developing proposals in internal factory and internal shop planning, inter-operational connections and transitions; designing and engineering development of machines, equipment, installations, devices, products; developing compositions of materials, alloys, other substances and

conducting their testing; developing technological processes, techniques and methods; consulting and author's supervision during installation supervision, commissioning and operation of equipment and facilities in general; consulting of an economic, financial or other nature.

The educational component "Research and Engineering of Packaging Equipment" primarily involves students mastering the basics of applying science-intensive computer engineering methods in the practice of designing packaging equipment.

Science-intensive computer engineering - primarily involves determining the performance and competitiveness of a development object at the design stage using modern CAD systems and computer software products for numerical analysis of its physical fields.

The purpose of the educational component "Research and Engineering of Packaging Equipment"

The purpose of the educational component is to form a complex of knowledge among students on the basics of applying science-intensive computer engineering methods in the practice of designing packaging equipment through the use of modern CAD systems and computational software products for numerical analysis of its physical fields.

Subject of the educational component "Research and Engineering of Packaging Equipment"

methods and tools of science-intensive computer engineering in terms of calculations and design during the development and design of packaging equipment.

Studying the educational component allows students to conduct theoretical research into packaging processes and packaging equipment using modern CAD-CAE design systems.

In accordance with the purpose, the training of masters in this specialty requires the strengthening of the formation of the following competencies:

Integral competence:

- The ability to solve complex tasks and problems in applied mechanics or in the learning process, which involves conducting research and/or implementing innovations and is characterized by uncertainty of conditions and requirements.

General competencies:

- Ability to identify, pose and solve engineering, technical and scientific and applied problems (ZK 01);
- Ability to learn and master modern knowledge (ZK 06);
- Ability to abstract thinking, analysis and synthesis (ZK 08);
- Based on knowledge of sustainable development problems, solve engineering tasks for technological equipment (ZK 11).

Professional competencies:

- The ability to apply appropriate methods and resources of modern engineering to find optimal solutions to a wide range of engineering problems using modern approaches, forecasting methods, information technologies and taking into account existing limitations under conditions of incomplete information and conflicting requirements (FC 01);
- The ability to describe, classify and model a wide range of technical objects and processes, based on deep knowledge and understanding of the theories and practices of mechanical engineering, as well as knowledge of related sciences (FC 02);
- Ability to engineer packaging equipment to ensure its performance under operational loads and environmental influences (FC 05);
- Ability to master new types of equipment and technology in the packaging industry and related industries (FC 09).

According to the requirements of the educational component program "Packaging Equipment Research and Engineering", after completing it, students must demonstrate the following program **learning outcomes**:

- Apply specialized conceptual knowledge of the latest methods and techniques for designing, analyzing and researching structures, machines and/or processes in the field of mechanical engineering and related fields of knowledge (PRN 01);
- Develop and put into production new types of products, in particular, perform research and development work and/or develop technological support for the process of their manufacture (PRN 02);
- Apply automation systems for conducting research, design and development work, technological preparation and engineering analysis in mechanical engineering (PRN 03);
- Use modern methods of optimizing the parameters of technical systems using systems analysis, mathematical and computer modeling, in particular under conditions of incomplete and contradictory information (PRN 04);
- Independently set and solve innovative problems, argue and defend the results obtained and decisions made (PRN 05);
- Develop, implement and evaluate innovative projects taking into account engineering, legal, environmental and social aspects (PRN 06);
- Master modern knowledge, technologies, tools and methods, in particular through independent study of professional literature, participation in scientific and technical and educational events (PRN 08);
- Be able to choose, determine processes and equipment for packaging products in consumer containers, for group packaging, fastening, transportation, dismantling (PRN 15);
- Choose the type and rational design of packaging equipment and its components based on the analysis of the features of the packaging technological process and the packaged product (PRN 18);
- Knowledge of methods of packaging various types of products and packaging equipment (PRN 21);
- Knowledge of the principles and methods of designing the main packaging and auxiliary equipment (PRN 23);
- Organize safe operation of packaging equipment based on technological regulations and using safety rules (PRN 27).

Also, the educational component "Packaging Equipment Research and Engineering" will allow students to learn to solve complex tasks and problems of applied mechanics during training, which involves conducting research on processes, equipment and/or implementing innovations in this field and is characterized by uncertainty of conditions and requirements.

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

Prerequisites: the educational component "Research and Engineering of Packaging Equipment" is based on the study of the following credit modules: "Higher Mathematics", "Physics", "Chemistry", "Engineering and Computer Graphics", "Theoretical Mechanics", "Informatics", "Materials Science", "Technology of Structural Materials", "Mechanics of Materials and Structures", "Theory of Mechanisms and Machines", "Theoretical Fundamentals of Heat Engineering", "Machine Parts and Fundamentals of Design", "Fluid and Gas Mechanics", "Engineering Calculations on a PC", "Technologies and Equipment for the Production of Packaging Materials", "Packaging Technologies and Equipment", "Automated Engineering Systems", "Processes, Apparatus and Machines of the Industry", "Packaging Equipment".

Postrequisites: the educational component "Research and Engineering of Packaging Equipment" provides the following educational components: "Packaging Equipment", "CAD of Technological Equipment", "Coursework on Packaging Equipment Engineering", "Scientific work on the topic of a master's thesis" and "Design of Production Lines", execution of master's theses.

3. Content of the educational component

Section 1. General information about packaging equipment engineering, designs, technological process and parametric calculations of equipment

Topic 1.1. Introduction to educational components. General provisions.

Topic 1.2. Dosing and packaging devices for products.

Topic 1.3. Dosing devices for bulk products.

Topic 1.4. Devices for dosing and packaging of liquid products.

Topic 1.5. Devices for dosing and packaging of viscous products.

Section 2. Mathematical models of physical fields of packaging technology processes and equipment for performing assessments of its operational suitability

Topic 2.1. Mathematical models of steady-state and non-steady-state problems of thermo-mechanics.

Topic 2.2. Multidisciplinary mathematical models.

Topic 2.3. Mathematical models of fluid and gas flow problems.

Topic 2.4. Mathematical models of discrete description of bulk material motion.

4. Educational materials and resources

Basic literature

1. Research and engineering of packaging equipment. [Electronic resource]: lecture notes: teaching aids for master's degree applicants in the educational program "Packaging and packaging equipment engineering" speciality 131 "Applied mechanics" / A. Ya. Karvatsky; Igor Sikorsky Kyiv Polytechnic Institute. – 2nd ed. revised – Electronic text data (1 file: 2.73 MB). Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2024. 143 p. URL : <https://ela.kpi.ua/handle/123456789/74720>
2. Gavva O. M., Bepalko A. P., Volochko A. I. Packaging equipment in 3 volumes – 1 volume. Equipment for packaging products in consumer packaging: a manual: edited by O. M. Gavva. Kyiv: IAC "Packaging", 2008. 436 p.
3. Dassault Systems SolidWorks Corporation, a Dassault Systems S.A. company, 300 Baker Avenue, Concord, Massachusetts 01742 USA, 1995–2009, 534 p.
4. Research and engineering of packaging equipment. [Electronic resource] : course project : teaching. manual. for master's degree applicants in the educational program "Engineering of packaging and packaging equipment" spec. 131 "Applied mechanics" / A. Ya. Karvatsky, V. M. Vytvytsky; Igor Sikorsky Kyiv Polytechnic Institute. – 2nd ed. revised. – Electronic. text. data (1 file: 1.44 MB). – Kyiv : Igor Sikorsky Kyiv Polytechnic Institute, 2024. 48 p. URL : <https://ela.kpi.ua/handle/123456789/74720>
5. Methodological instructions for the implementation of computer workshops for practical classes of students in the discipline "Design of production lines", for students specializing in "Machinery and packaging technology" / A.Ya. Karvatsky, T.V. Lazarev. Kyiv: NTUU "KPI", 2013. 35 p. URL : https://cpsm.kpi.ua/Doc/Metod_Pract_PPL.pdf

Additional literature

1. SOLIDWORKS: Drawings Online Class. URL : <https://www.linkedin.com/learning/solidworks-drawings>
2. Hanlon J.F., Kelsey R. J. Handbook of Package Engineering: 3rd Edition. London : CRC Press, 1998. 698 p. URL : <https://www.amazon.com/Handbook-Package-Engineering-Joseph-Hanlon/dp/1566763061>
3. Introduction to SolidWorks. 2014. · 207 p. · URL : <https://www.pdfdrive.com/introduction-to-solidworks-e13723438.html>
4. SolidWorks Simulation. 2010. 146 p. URL : <https://www.pdfdrive.com/solidworks-simulation-e17219094.html>
5. Tickoo Sham. Solidworks A Tutorial Approach. 2016, 593 p. URL : <https://www.pdfdrive.com/solidworks-a-tutorial-approach-e175343946.html>

6. Website: Autodesk Inventor. URL : <http://www.autodesk.ru/products/autodesk-inventor-family/overview>
7. Segerlind Larry J. *Applied Finite Element Analysis* ; sec. edit. New York : John Wiley & Sons, Inc., 1984. 393 p. URL : <https://www.scribd.com/doc/241729488/Applied-Finite-Element-Analysis-Larry-J-Segerlind-pdf>
8. Zienkiewicz, O., Taylor, R., Fox, D.: *The Finite Element Method for Solid and Structural Mechanics*. 7th edn. Elsevier Ltd., Oxford (2014).
9. Website: PTC Mathcad – a software environment for performing various mathematical and technical calculations on a computer. URL : <http://www.ptc.com/product/mathcad/>
10. Finite element method in problems of mechanics of continua. Laboratory practical course on the academic discipline [Electronic resource]: teaching aids for students of specialties 131 "Applied mechanics", 133 "Industrial mechanical engineering", specializations "Engineering, computer modeling and design of packaging equipment", "Engineering, computer modeling and design of equipment for the production of polymer and building materials and products" / A. Ya. Karvatsky. Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2018. 391 p. URL : <https://ela.kpi.ua/handle/123456789/11636>
11. Mechanics of continua. [Electronic resource]: lecture notes: teaching aids for master's degree applicants in educational programs "Packaging and packaging equipment engineering" speciality 131 "Applied mechanics" and "Engineering and computer-integrated technologies for designing innovative industry equipment" speciality 133 "Industrial mechanical engineering" / A. Ya. Karvatsky, A. O. Chemerys; Igor Sikorsky Kyiv Polytechnic Institute. – 2nd ed. revised and supplemented – Electronic text data (1 file: 3.56 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2024. 214 p. URL : <https://ela.kpi.ua/handle/123456789/72094>
12. Modeling of statics and dynamics of bulk materials in LIGGGHTS [Electronic resource]: a manual for master's degree applicants in specialties 131 Applied Mechanics, 133 Industrial Mechanical Engineering / A. Ya. Karvatsky, I. O. Mikulyonok, V. M. Vytvytsky; Igor Sikorsky Kyiv Polytechnic Institute. – Electronic text data (1 file: 4.16 MB). – Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2021. 76 p. URL : <https://ela.kpi.ua/handle/123456789/45613>

Information resources on the Internet

1. DSpace STL Igor Sikorsky Kyiv Polytechnic Institute, <http://ela.kpi.ua/handle/123456789/23915>, <http://ela.kpi.ua/handle/123456789/23914>, <https://ela.kpi.ua/handle/123456789/11636>, <https://ela.kpi.ua/handle/123456789/19011>
2. Website: Department of Chemical, Polymeric and Silicate Engineering, <http://cpsm.kpi.ua/mr.html>
3. Campus Igor Sikorsky Kyiv Polytechnic Institute, <http://login.kpi.ua/>
4. Distance learning platform "Sikorsky", <https://sikorsky-distance.kpi.ua/>

5. Methodology for mastering the educational component

Lecture classes

Lectures are aimed at:

- providing modern, holistic, interdependent knowledge on the educational component "Research and Engineering of Packaging Equipment", 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;
- educating students in professional and business qualities and developing their independent creative thinking;
- forming the necessary interest in students and providing a direction for independent work;
- determining the current level of development of science in the field of modern methods of knowledge-intensive computer engineering in the practice of packaging equipment design;
- reflecting the methodological processing of the material (highlighting the main provisions, conclusions, recommendations, clear and adequate wording);
- using visual materials for demonstration, combining them, if possible, with the demonstration of results and samples;
- teaching research materials in a clear and high-quality language with compliance with structural and logical connections, explaining all newly introduced terms and concepts;
- accessibility for perception by a given audience.

No s/p	The name of the lecture topic and the list of main issues (links to literature and tasks on the IWS)	Number of hours
Section 1. General information about packaging equipment engineering, designs, technological process and parametric calculations of equipment		
1	Topic 1.1. Introduction to educational components. General provisions <u>Lecture 1.</u> Introduction. Literature. Basic concepts and definitions. Terminological apparatus of engineering. Main trends and approaches of modern computer engineering and the place of the educational component of Engineering Education. General characteristics of the packaging process. Classification of packaging equipment. Technological process of packaging. Characteristics of products as a packaging object. <u>List of didactic aids:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Drawings, posters for the lecture. <u>Tasks for the IWS.</u> CAD-CAE systems and technologies. Literature: [3], [A5] p. 3–25; [A1] p. 3–30; General data on consumer packaging. Literature: [2] p. 18–20; lecture notes [1], p. 20–26.	2
2	Topic 1.2. Dosing and packaging devices <u>Lecture 2.</u> Dosing methods. Classification of dosing devices. Dosing accuracy. <u>List of didactic aids:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Drawings, posters for the lecture. <u>Tasks for the IWS.</u> The nature of systematic and random dosing errors. Conditions for choosing a dosing method and the design of the dispenser. Literature: [2] pp. 24–30; lecture notes [1], pp. 26–42.	4
3	Topic 1.3. Bulk product dosing devices <u>Lecture 3.</u> General characteristics of bulk product dosing. Volumetric type dosing devices. Cup type dosing device. Gate type dosing device. Chamber type dosing device. Pendulum type dosing device. Auger type dosing device. Methodology of technological (parametric) calculation of volumetric type dosing devices. Devices for weighing dosing of bulk products. Classification and arrangement of weighing dosing devices for bulk products. Belt feeders. Vibrating feeders. Screw	4

No s/p	The name of the lecture topic and the list of main issues (links to literature and tasks on the IWS)	Number of hours
	feeders. Plate type feeders. <u>List of didactic aids:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Drawings, posters for the lecture. <u>Tasks for the IWS.</u> Typical design schemes of volumetric dosing devices, schemes of their layout in packaging machines. Methods of improving volumetric dosing devices. Literature: [2] pp. 31–49; Drive power of a volumetric feeder of the carousel type. Literature: [2] p. 49–53; Static and dynamic loads during weighing. Minimum mass of bulk products of the feeder. Literature: [2] p. 53–60; Technological calculations of belt and vibrating feeders. Literature: [2] p. 60–72; Rotary feeders, electromagnetic vibrating feeding devices, linear-tray, combined type. Literature: [2] p. 72–97; lecture notes [1], p. 42–84.	
4	Topic 1.4. Devices for dosing and packaging liquid products <u>Lecture 4.</u> Classification and characteristics of the process of dosing liquid products. Devices for barometric isobaric packaging. Parametric calculations of packaging devices for liquid products. <u>List of didactic aids:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Drawings, posters for the lecture. <u>Tasks for the IWS.</u> Design features of devices for dosing and packaging liquid products in soft and semi-rigid containers, disposable tanks. Literature: [2] pp. 98–187; lecture notes [1], pp. 84–96.	4
5	Topic 1.5. Devices for dosing and packaging viscous products <u>Lecture 5.</u> Classification features of viscous products as a packaging object. Classification and analysis of the structures of viscous product dosing and packaging devices. Typical structural diagrams of membrane and piston type dispensers. Technological calculation of piston type dosing devices. <u>List of didactic aids:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Drawings, posters for the lecture. <u>Tasks for the IWS.</u> Devices for dosing and packaging viscous products. Literature: [2] pp. 212–232; lecture notes [1], pp. 97–106.	4
Section 2. Mathematical models of physical fields of packaging technology processes and equipment for performing assessments of its operational suitability		
6	Topic 2.1. Mathematical models of stationary and non-stationary problems of thermo-mechanics <u>Lecture 6.</u> Formulation of the problem of stationary heat conduction. Formulation of the problem of static elasticity. Formulation of the problem of unsteady heat conduction. Formulation of the problem of dynamic elasticity taking into account large deformations and contact interaction of mechanical nature. <u>List of didactic aids:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Drawings, posters for the lecture. <u>Tasks on the IWS.</u> Physical and geometric equations. Initial and boundary conditions in thermomechanics problems. Literature: [6], pp. 8–9, pp. 15–17; [5], pp. 6–10; lecture notes [1], pp. 107–115.	2
7	Topic 2.2. Multidisciplinary mathematical models <u>Lecture 7.</u> Formulation of a nonlinear non-stationary thermoelectric problem. Formulation of a coupled thermoelasticity problem. <u>List of didactic aids:</u> A laptop with an electronic version of the lecture and a projector are used at the lecture. Drawings, posters for the lecture. <u>Tasks on the IWS.</u> Initial and boundary conditions in multidisciplinary problems. Literature: [7], pp. 116–119; lecture notes [1], pp. 115–119.	2

No s/p	The name of the lecture topic and the list of main issues (links to literature and tasks on the IWS)	Number of hours
8	Topic 2.3. Mathematical models of liquid and gas flow problems <u>Lecture 8.</u> Formulation of the problem of thermal-hydrodynamics during laminar flow of an incompressible Newtonian fluid. Formulation of the problem of thermal-hydrodynamics during turbulent flow of an incompressible Newtonian fluid based on the standard model. Physical equations for a non-Newtonian fluid. Models of dilatant (composite) substances. Formulation of the problem of the thermal-hydrodynamic state of a Bingham-Papanastasiou type fluid. Mathematical model of the process of impregnation of porous media during the manufacture of composite containers. <u>List of didactic aids:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Drawings, posters for the lecture. <u>Tasks for the IWS.</u> Physical equations. Initial and boundary conditions in thermal-hydrodynamics problems. Literature: lecture notes [1], pp. 120–132.	4
9	Topic 2.4. Mathematical models of discrete description of the motion of bulk material <u>Lecture 9.</u> Formulation of the problem of a moving layer of bulk material. <u>List of didactic aids:</u> The lecture uses a laptop with an electronic version of the lecture and a projector. Drawings, posters for the lecture. <u>Tasks for the IWS.</u> Initial and boundary conditions in the problem of the movement of bulk material. Literature: lecture notes [1], pp. 130–133; [8].	4
Total		30

Practical classes

The main goals of the practical training cycle are for students to apply theoretical knowledge in the design of packaging equipment, to acquire skills in using CAD systems (SolidWorks [3], [A1, A3–A5], Autodesk Inventor [A6], Mathcad [A9]) and SolidWorks CAE software products to build complex numerical models of components and parts of packaging machines, to analyze the results of calculations of physical fields during the design process in order to determine the operational suitability of the parts and components being developed.

No s/p	The name of the topic of practical classes and the list of main issues (reference to literature and tasks on the IWS)	Number of hours
1	Topic 1. Introduction to SolidWorks, basics of 3D modeling, creation (drawing) of sketches. Literature: [3], pp. 32–59, 61, 62. <u>List of didactic tools:</u> personal computer, SolidWorks CAD system, examples of building sketches and solid models of parts. <u>Tasks on the IWS.</u> Two-dimensional drawing. Drawing horizontal and vertical lines. Drawing using forming lines. Literature: [3], [5], [A1, A3–A5].	2
2	Topic 2. Elements: elongated boss/base and elongated cutout. Literature: [4], p. 64–87, 103–105. <u>List of didactic tools:</u> personal computer, SolidWorks CAD system, examples of building sketches and solid-state models of parts. <u>Tasks on IWS.</u> Basics of part modeling. Plate. Cutouts. Base bracket. Literature: [3], [5], [A1, A3].	4
3	Topic 3. 3D part. Literature: [3], p. 110–146, 147, 159. <u>List of didactic tools:</u> personal computer, SolidWorks CAD system, examples of building sketches and solid-state models of parts. <u>Tasks on IWS.</u> Modeling of castings and stampings. Tool holder. Pulley. Literature: [3], [5], [A1, A5].	2

No s/p	The name of the topic of practical classes and the list of main issues (reference to literature and tasks on the IWS)	Number of hours
4	Topic 4. Axisymmetric elements and elements along the trajectory. Literature: [3], p. 190–208, 230, 234–236, 239–240. <u>List of didactic tools:</u> personal computer, SolidWorks CAD system, examples of building sketches and solid-state models of parts. <u>Tasks on IWS.</u> Elements "to rotate". Flange. Guide. Elements "along the trajectory" - paper clip. Literature: [3], [5], [A1, A5].	4
5	Topic 5. Independent work – shaft. Literature: [3]. <u>List of didactic tools:</u> personal computer, CAD systems Autodesk Inventor, SolidWorks, shaft drawings. <u>Tasks on IWS.</u> Construction of solid-state models of parts according to drawings. Literature: [3], [4], [A1, A5].	2
6	Topic 6. Assembling parts into machine and device assemblies. Literature: [3], <u>List of didactic aids:</u> personal computer, CAD systems Autodesk Inventor, SolidWorks, solid-state models of parts, pictures of assemblies. <u>Tasks on IWS.</u> Modeling assemblies from the bottom up. Conjugation. Coffee grinder. Reducer. Literature: [3], [4], [A1, A5].	4
7	Topic 7. Making drawings based on solid models of parts and assemblies. Literature: [A1], p.1-1–1-27 (5-33), p. 3-1–3-27 (53-79), p. 4-1–4-11 (92-104), p. 8-1–8-8 (158-165). <u>List of didactic tools:</u> personal computer, CAD systems Autodesk Inventor, SolidWorks, solid models of parts. <u>Tasks on IWS.</u> Basics of creating a drawing based on a 3D object model. Creating drawing views ("Rocking chair", "Body"). Representing the main dimensions of the part ("Rocking chair", "Body"). Creating an assembly drawing. Literature: [3]–[5], [A1, A5].	4
8	Topic 8. Creating a 3D object and drawing based on a real (existing) part. Literature: [2]–[5], [A1, A5]. <u>List of didactic tools:</u> personal computer, CAD systems Autodesk Inventor, SolidWorks, various parts, ruler, compasses. <u>Tasks on IWS.</u> Assembly. Review of the material covered. Literature: [3]–[5], [A1, A3–A5].	6
9	Modular control work	2
Total		30

Seminar classes

The working curriculum does not include seminar classes.

Laboratory classes

The working curriculum does not include laboratory classes.

6. Student independent work

No s/p	Name of the topic submitted for self-study	Number of hours of IWS
1	Topic 1.1. Introduction to the educational component. General provisions CAD-CAE systems and technologies. Literature: [3], [A5] pp. 3–25; [A1] pp. 3–30; General data on consumer packaging. Literature: [2] pp. 18–20; lecture notes [1], pp. 20–26. Two-dimensional drawing. Drawing horizontal and vertical lines. Drawing using forming lines. Literature: [3], [5], [A1, A3–A5].	9

No s/p	Name of the topic submitted for self-study	Number of hours of IWS
2	Topic 1.2. Dosing and packaging devices <i>The nature of systematic and random dosing errors. Conditions for choosing a dosing method and the design of the dispenser. <u>Literature</u>: [2] p. 24–30; lecture notes [1], p. 26–42.</i> <i>Fundamentals of part modeling. Plate. Cutouts. Bracket base. <u>Literature</u>: [3], [5], [A1, A3].</i>	9
3	Topic 1.3. Bulk product dosing devices <i>Typical design schemes of volumetric feeders, schemes of their layout in packaging machines. Ways to improve volumetric feeders. <u>Literature</u>: [2] pp. 31–49; Drive power of a volumetric feeder of a carousel type. <u>Literature</u>: [2] pp. 49–53; Static and dynamic loads during weighing. Minimum mass of bulk products of the feeder. <u>Literature</u>: [2] pp. 53–60; Technological calculations of belt and vibrating feeders. <u>Literature</u>: [2] pp. 60–72; Rotary feeders, electromagnetic vibrating feeding devices, linear-tray, combined type. <u>Literature</u>: [2] pp. 72–97; lecture notes [1], pp. 42–84.</i> <i>Modeling of castings and stampings. Tool holder. Pulley. <u>Literature</u>: [3], [5], [A1, A3–A5].</i>	9
4	Topic 1.4. Devices for dosing and packaging liquid products <i>Design features of devices for dosing and packaging liquid products in soft and semi-rigid containers, disposable tanks. <u>Literature</u>: [2] pp. 98–187; lecture notes [1], pp. 84–96.</i> <i>Elements “to turn”. Flange. Guide. Elements “along the trajectory” – paper clip. <u>Literature</u>: [3], [5], [A1, A3–A5].</i>	9
5	Topic 1.5. Devices for dosing and packaging viscous products <i>Devices for dosing and packaging viscous products. <u>Literature</u>: [2] pp. 212–232; lecture notes [1], pp. 97–106.</i> <i>Construction of solid-state models of parts from drawings. <u>Literature</u>: [3], [4], [A1–A3].</i>	5
6	Topic 2.1. Mathematical models of stationary and non-stationary problems of thermo-mechanics <i>Physical and geometric equations. Initial and boundary conditions in thermomechanical problems. <u>Literature</u>: [6], pp. 8–9, pp. 15–17; [5], pp. 6–10; lecture notes [1], pp. 107–115.</i> <i>Bottom-up modeling of assemblies. Conjugation. Coffee grinder. Reducer. <u>Literature</u>: [3], [4], [A1, A3–A5].</i> <i>Numerical analysis of the physical fields of packaging equipment using CAE systems. <u>Literature</u>: [4], [5].</i>	5
7	Topic 2.2. Multidisciplinary mathematical models <i>Initial and boundary conditions in multidisciplinary problems. <u>Literature</u>: [7], pp. 116–119; lecture notes [1], pp. 115–119.</i> <i>Fundamentals of creating a drawing based on a 3D object model. Creating drawing views (“Rocking chair”, “Body”). Representing the main dimensions of a part (“Rocking chair”, “Body”). Creating an assembly drawing. <u>Literature</u>: [3]–[5], [A1, A3–A5].</i> <i>Performing a numerical analysis of the fissile fields of packaging equipment using CAE systems. <u>Literature</u>: [4], [5].</i>	4
8	Topic 2.3. Mathematical models of liquid and gas flow problems <i>Physical equations. Initial and boundary conditions in thermal-hydrodynamics problems. <u>Literature</u>: lecture notes [1], pp. 120–132.</i>	4

No s/p	Name of the topic submitted for self-study	Number of hours of IWS
	<i>Assembly execution. Review of the material covered. Literature: [3]–[5], [A1–A3]. Numerical analysis of physical fields of packaging equipment using CAE systems. Literature: [4], [5].</i>	
9	Topic 2.4. Mathematical models of discrete description of the motion of bulk material <i>Initial and boundary conditions in the problem of bulk material motion. Literature: lecture notes [1], pp. 130–133; [8]. Numerical analysis of physical fields of packaging equipment using CAE systems. Literature: [4], [5].</i>	2
10	Modular control work	4
11	Exam	30
Total		90

Individual tasks

The working curriculum does not provide for individual assignments.

Control works

The purpose of the modular test:

- summary of the study of the topics of the credit module;
- application of the acquired knowledge to perform engineering calculations;
- ability to independently apply the acquired knowledge to perform tasks in this credit module and in other educational components: “Packaging equipment”, “Design of production lines”, “CAD of technological equipment”, “Course work on packaging equipment engineering”, “Scientific work on the topic of the master's thesis”.

The working curriculum of the educational component provides for one modular test, which covers sections 1 and 2. An approximate list of questions for the MCW is given in the additional information of the syllabus of the educational component. The formulation of questions for the MCW may be slightly changed in accordance with the features of teaching the lecture material and its perception by students. In order to prepare students in the IWS mode, the teacher familiarizes them with the questions for the MCW 1–2 weeks before performing the work.

Politics and control

7. Educational component policy

Rules for attending classes and behavior in classes

Attending classes is a mandatory component of 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 to conduct classes, not to be distracted by actions that are not related to the educational process.

Rules for the implementation and protection of practical work (computer workshops):

- practical work (computer workshops) takes place during hours of practical classes and SRS and is sent to the teacher's e-mail or telegrams;
- practical work (computer workshops) takes place during hours of practical classes and SRS and is sent to the teacher's e-mail or telegrams;
- rules for the protection of practical works (computer workshops) are based on a rating system for assessing learning outcomes.

Rules for assigning incentive and penalty points:

- encouraging points can be credited by the teacher for active participation in lectures, preparation of scientific publications on topics of the discipline. At the same time, the amount of incentive points may not exceed 25% of the rating scale.
- penalty points within the discipline are not provided.

Deadline and overlay policy

In case of debts in the discipline or any force majeure circumstances, students should contact the teacher through accessible (provided by the teacher) communication channels to solve problematic issues and coordinate the algorithm of actions for working out.

Academic Integrity Policy

Violation of the Code of Academic Integrity of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" is a serious violation, even if it is unintentional. The Code is available at the link: <https://kpi.ua/code.3>.

In particular, compliance with the Code of Academic Integrity means that all work in exams and tests must be performed individually. When doing independent work, students can consult with teachers and other students, but must independently solve problems, guided by their own knowledge, skills and abilities. References to all resources and sources (e.g. in reports from computer workshops, independent work or presentations) should be clearly defined and properly executed. That is, it is unacceptable to have no references when using printed and electronic materials, quotes, opinions of other authors.

Policy of academic behavior and ethics

Students should be tolerant, respect the opinion of others, object to formulate in the correct form, constructively maintain feedback in the classroom.

The norms of ethical behavior of students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". More: <https://kpi.ua/code.2>.

1. Types of control and rating system for assessing learning outcomes (RS)

Distribution of educational time by types of classes and tasks from the credit module according to the working curriculum:

Semester	School time		Distribution of training hours				Control measures		
	credit	acad. h.	Lecture	Pract.	Ind.less.	IWS	MCW	HCW	Semester certification
1	5	150	30	30	–	90	1	–	Exam

Current control: answers to express control questions, reports from computer workshops, modular control work.

Calendar control: carried out twice a semester as a monitoring of the current status of implementation of the syllabus requirements.

Semester control: exam.

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

- 1) answers to the questions of express control of theoretical material (4 express control is carried out);
- 2) implementation of design and design works (computer workshops) in practical classes (8 works in total);
- 3) modular control work.
- 4) answer to the exam (written).

System of rating (weight) points and evaluation criteria

1. Express control:

- “excellent”, complete answer (at least 90% of the required information) – 2 points;

- “good”, sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies – 1 point;
- “unsatisfactory”, unsatisfactory answer (does not meet the requirements for 1 point) – 0 points.

2. Practical classes:

- “excellent”, creative execution of the task, fluent mastery of the material – 4-5 points;
- “good”, execution of the task in full, but with minor errors – 3 points;
- “satisfactory”, execution of the task with individual errors – 2 points;
- “unsatisfactory”, failure to complete the task – 0 points.

3. Modular control work:

- “excellent”, complete answer (at least 90% of the required information) – 11-12 points;
- “good”, sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies – 8-9 points;
- “satisfactory”, incomplete answer (at least 60% of the required information) and minor errors – 6-7 points;
- “unsatisfactory”, unsatisfactory answer – 0 points.

One or two best students in each practical session may be given 1–2 incentive points; +5 incentive points for a report on the results of studying the educational component at a student conference or publication in a journal.

The maximum sum of points for the starting component is 50. A prerequisite for admission to the exam is the completion of all tasks of practical sessions and the submission of the calculation work and a starting rating of at least 25 points.

According to the results of the educational work for the first 7 weeks, the “ideal student” must score 25 points. At the certification (8th week), the student receives “credited” if his current rating is at least 12 points.

According to the results of 15 weeks, the “ideal student” should score 50 points. At the second certification (week 14), the student receives “passed” if his current rating is at least 25 points.

The maximum amount of points for the semester R is 50 (where $R = r_{e-kp} \cdot 4 + r_{pr} \cdot 6 + r_{mkr} = 2 \cdot 4 + 5 \cdot 6 + 12 = 8 + 30 + 12 = 50$).

At the exam, students complete a written test. Each task contains two theoretical questions and one practical one. The list of questions is given in the methodological recommendations for mastering the credit module. Each theoretical question is evaluated at 15 points, and the practical one is evaluated at 20 points.

Theoretical question grading system (r_{T1} , r_{T1}):

- “excellent”, complete answer (at least 90% of the required information) – 15-14 points;
- “good”, sufficiently complete answer (at least 75% of the required information or minor inaccuracies) – 13-11 points;
- “satisfactory”, incomplete answer (at least 60% of the required information and some errors) – 10-9 points;
- “unsatisfactory”, unsatisfactory answer – 0 points.

Practical assignment evaluation system (r_{pr}):

- “excellent”, complete error-free solution of the task (at least 90% of the required information) – 20-18 points;
- “good”, complete solution of the task with insignificant inaccuracies (at least 75% of the required information or minor inaccuracies) – 17-15 points;

- “satisfactory”, the task was completed with certain shortcomings (at least 60% of the required information and some errors) – 14-12 points;
 - “unsatisfactory”, the task was not completed – 0 points.
- The maximum rating for the examination test is**

$$r_E = r_{T1} + r_{T2} + r_{pr} = 15 + 15 + 20 = 50 \text{ points.}$$

Admission requirements for semester examination: semester rating of at least 25 points.

The sum of the starting points and the points for the examination test is converted into the examination grade according to the table:

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

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

9. Additional information on the educational component

List of questions submitted for semester control

Theoretical questions

1. Describe the terminology of engineering. The term "engineering" - what should be understood by it?
2. Describe the definition of knowledge-intensive computer engineering, its methodology and tools?
3. Describe the composition of the innovative M3 concept and what it consists of?
4. Analyze the place of the educational component “Research and Engineering of Packaging Equipment” in the innovative M3 concept?
5. Describe the main stages of the application of knowledge-intensive computer engineering within the educational component “Research and Engineering of Packaging Equipment”.
6. Analyze the general characteristics of the packaging process.
7. Describe the classification of packaging equipment.
8. Analyze the technological process of packaging.
9. Analyze the characteristics of products as a packaging object based on rheological or physical equations.
10. Describe the methods of dosing.
11. Analyze the criteria for classifying dosing devices.
12. Analyze the factors that affect dosing accuracy. Provide a method for assessing the dosing error of products.
13. Analyze the general characteristics of the dosing process of bulk products.
14. Analyze volumetric dosing devices and their principles of operation.
15. Analyze a typical structural diagram of a cup-type doser and its principle of operation.
16. Analyze a typical structural diagram, principle of operation and characterize slide-type dosers.
17. Analyze a typical structural diagram, principle of operation and characterize chamber-type dosers.
18. Analyze a typical structural diagram, principle of operation and characterize pendulum-type dosers.
19. Describe the scope and typical structural diagram of screw dosers and their principle of operation.
20. Analyze the method of parametric calculation of volumetric type dispensers.

21. Analyze what is the difference in the methods of calculating the drive power in the case of a linear arrangement of the feeder, compared to a carousel arrangement?
22. Describe the structure of weighing dosing devices, the peculiarity of forming a dose of bulk products?
23. Analyze how the operation of the feeder affects the quality of dose formation?
24. Analyze how to determine the speed of product movement by the feeder, at which the highest accuracy of dosing is ensured?
25. Analyze the characteristics of the qualification features of weighing feeders.
26. Describe the methods of unloading weighing containers, their advantages and disadvantages.
27. Analyze the purpose of feeders for bulk products.
28. Describe the disadvantages of bulk product unloading schemes and indicate ways to overcome them.
29. Analyze the classification and describe the device of weighing feeders for bulk products.
30. Analyze a typical diagram of belt feeders and their technological calculation.
31. Analyze the disadvantages of inertial transport devices.
32. Analyze the purpose, principle of operation and design scheme of vibrating feeders.
33. Analyze the requirements for the design of vibrating feeders.
34. Describe the method of parametric calculation of vibrating feeders.
35. Analyze the purpose, principle of operation and design scheme of a screw feeder.
36. Analyze the method of technological calculation of a screw feeder.
37. Analyze the purpose, principle of operation and design scheme of a plate-type feeder.
38. Analyze the method of technological calculation of a plate-type feeder.
39. Describe the design schemes and principle of operation of rotary feeders.
40. Analyze the features of the design of a rotary feeder for moving difficult-to-flow products.
41. Describe the designs and operating principle of electromagnetic vibrating feeders.
42. Describe the designs and operating principle of combined type feeders.
43. Analyze by what features can liquid products be classified as a packaging object?
44. Analyze the classification and main characteristics of the liquid product dosing process.
45. Analyze in what types of containers are liquid products packaged?
46. Describe devices for barometric isobaric packaging.
47. Analyze the designs and operating principle of devices with measuring cups and a valve system.
48. Analyze the calculation method of liquid product packaging devices.
49. Analyze the hydraulic diagrams of liquid product dosing and packaging devices.
50. Analyze the methods for determining the pressure loss coefficient of dosing and packaging devices for liquid products.
51. Analyze by what features can viscous products be classified as a packaging object?
52. Analyze in what types and types of packaging are viscous products packaged?
53. Describe the types of dispensers used for dosing viscous products?
54. Describe the features by which dosing and packaging devices for viscous products are classified?
55. Describe a typical design scheme of a membrane dispenser.
56. Describe a typical design scheme of a piston dispenser.
57. Analyze the methodology for technological calculation of piston-type viscous product dosing devices.
58. Analyze by what structural and mechanical parameters can plastic products be characterized?
59. Analyze by what criteria can plastic products be classified as a packaging object?
60. Analyze by what criteria are dosing and packaging devices for plastic products classified?
61. Analyze the formulation of the linear problem of the stationary thermal conductivity of an isotropic material.
62. Analyze the statement of the static elasticity problem.
63. Analyze the mathematical formulation of the nonlinear problem of non-stationary heat conduction.
64. Describe the statement of the dynamic elasticity problem taking into account large deformations.

65. Describe the statement of the nonlinear non-stationary thermoelectric problem for an isotropic material.
66. Analyze the statement of the coupled thermoelasticity problem.
67. Analyze the statement of the thermal-hydrodynamics problem during laminar flow of an incompressible Newtonian fluid.
68. Analyze the statement of the thermal-hydrodynamics problem during turbulent flow of an incompressible Newtonian fluid based on the standard $k - \varepsilon$ model.
69. Describe the physical equations for a non-Newtonian fluid.
70. Describe the main models of dilatant (composite) substances.
71. Analyze the formulation of the problem of the thermal-hydrodynamic state of a composite fluid of the Bingham-Papanastasiou type.
72. Analyze the mathematical model of the process of impregnation of porous media during the manufacture of composite containers.
73. Analyze what is the main difference between the discrete and continuous representation of the movement of the medium?
74. Analyze the formulation of the problem of a moving layer of bulk material using MDE.

Practical tasks

1. Create a solid model and make a drawing for the given part. (The student determines the material and its physical properties independently). Perform a numerical analysis of the strength of the structure under a one-sided load with an external pressure of 100 kPa.
2. Create a solid model and make a drawing for the given part. Perform a numerical analysis of the strength of the structure under a temperature load of 130 °C.
3. Create a solid model and make a drawing for the given part or assembly. Perform a numerical analysis of the strength of the structure under a one-sided load with a torque of 20 N·m.
4. Create a solid model and make a drawing for the given part. Perform a numerical analysis of the strength of the structure under a temperature load of 200 °C.
5. Create a solid model and make a drawing for the given part or assembly. Perform a numerical analysis of the strength of the structure under a one-sided load with a torque of 60 N·m.
6. Create a solid model and make a drawing for the given part. Perform a numerical analysis of the strength of the structure under a one-sided load with an external pressure of 200 kPa.
7. Create a solid model and make a drawing for the given part or assembly. Perform a numerical analysis of the strength of the structure under a one-sided load with a torque of 110 N·m.
8. Create a solid model and make a drawing for the given part. Perform a numerical analysis of the strength of the structure under a one-sided load with a torque of 150 N·m and a one-sided load with an external pressure of 250 kPa.
9. Create a solid model and make a drawing for the given part. Perform a numerical analysis of the structural strength under the condition of a temperature load of 140 °C and a one-sided external pressure load of 150 kPa.
10. Create a solid model and make a drawing for the given part. Perform a numerical analysis of the structural strength under the condition of a one-sided external pressure load of 450 kPa and a temperature load of 40 °C.
11. Create a solid model and make a drawing for the given part or assembly. Perform a numerical analysis of the structural strength under the condition of a one-sided torque load of 350 N·m.
12. Create a solid model and make a drawing for the given part. Perform a numerical analysis of the structural strength under the condition of a one-sided external pressure load of 1200 kPa.
13. Create a solid model and make a drawing for the given part or assembly. Perform a numerical analysis of the structural strength under unilateral loading with an external pressure of 200 kPa.
14. Create a solid model and draw a drawing for the given part or assembly. Perform a numerical analysis of the structural strength under bilateral loading with external pressures of 1000 and 200 kPa.

15. Create a solid model and draw a drawing for the given part. Perform a numerical analysis of the safety margin of the part under loading with a torque of 150 N·m.

List of issues and tasks submitted for modular control work

1. Describe the term "engineering" – what should be understood by it?
2. Describe the definition of science-intensive computer engineering, its methodology and tools?
3. Analyze the composition of the innovative M^3 concept and what is it?
4. Analyze what place does the discipline "Research and engineering of packaging equipment" occupy in the innovative M^3 concept?
5. Analyze the main stages of the use of high-science computer engineering within the discipline "Research and engineering of packaging equipment".
6. Analyze the stages that make up the technological process of packaging products?
7. Analyze what are the ways to pack products?
8. Analyze the basic and auxiliary operations performed by packaging machines during product packaging.
9. Analyze which functional modules make up the packaging machine?
10. Analyze what factors determine the structure of the packaging machine?
11. Analyze the directions of classification of packaging equipment.
12. Analyze what functions do consumer packaging of products perform?
13. Describe the types and types of packages.
14. Analyze which of the most important properties of products affect the choice or creation of packaging machines?
15. Describe the simplest types of deformed environments.
16. Describe dispersed multiphase media.
17. Analyze which main groups are the packaged products divided into?
18. Analyze what the dosing process is?
19. Analyze the methods of dosing products.
20. Describe the volumetric, weight and combined methods of dosing.
21. Analyze what is the dosage with correction according to a given parameter?
22. Analyze the signs by which the classification of dispensers is performed.
23. Analyze the groups into which dosing devices are divided depending on their design and type of movement of working organs?
24. Describe the term "dosage accuracy".
25. Analyze the factors affecting the accuracy of the dosage.
26. Analyze the factors affecting the accuracy of the dosage.
27. Analyze the factors affecting the amount of systematic and random errors of the dosage.
28. Analyze the formulas to determine absolute, systematic, random and complete absolute errors.
29. Analyze ways to reduce systematic error.
30. Analyze the conditions for choosing the method of dosing and the design of dispensers.
31. Analyze the signs by which the bulk products are classified as an object of packaging.
32. Analyze the types and types of packaging in which bulk products are packaged.
33. Describe the types of dispensers used for dosing bulk products.
34. Describe the work of the volume-type dispenser, the principle of dose formation.
35. Analyze the typical constructive scheme of the cup-type dispenser.
36. Analyze the layout schemes of cup dispensers in packaging machines.
37. Analyze the typical design scheme of cup dispensers with carousel layout.

38. Analyze the typical design scheme of cup dispensers with linear layout.
39. Analyze and give the advantages and disadvantages of cup dispensers, their scope.
40. Analyze the typical design scheme and give a description of the chimber type dispensers.
41. Analyze the typical design scheme and give a description of camera-type dispensers.
42. Analyze the typical design scheme and give a description of pendulum type dispensers.
43. Analyze and give the scope and typical design scheme of screw dispensers.
44. Describe ways to improve screw dispensers.
45. Analyze the method of parametric calculation of volumetric dispensers.
46. Analyze what is the difference in the methods of calculating the power of the drive in the case of linear layout of the dispenser, compared to the carousel layout?
47. Describe the structure of devices for weight dosage, a feature of the formation of a dose of bulk products.
48. Analyze how the work of the feeder affects the quality of dose formation?
49. Analyze ways to determine the speed of movement of products by the feeder, which ensures the highest dosage accuracy.
50. Analyze the characteristics of the qualification signs of weight dispensers.
51. Describe the ways of unloading weighing tanks, their advantages and disadvantages.
52. Describe the purpose of nutrients bulk products.
53. Describe the shortcomings of the schemes of unloading bulk products and provide ways to overcome them.
54. Analyze the classification and describe the device of weight dispensers of bulk products.
55. Analyze the typical scheme of tape feeders and their technological calculation.
56. Analyze the shortcomings of inertial transportation devices.
57. Analyze the purpose, principle of operation and constructive scheme of vibration feeders.
58. Describe the requirements for the design of vibration feeders.
59. Describe the method of parametric calculation of vibration feeders.
60. Analyze the purpose, principle of operation and design scheme of the screw feeder.
61. Analyze the method of technological calculation of the screw feeder.
62. Analyze the purpose, principle of operation and design scheme of the plate-type feeder.
63. Analyze the method of technological calculation of the rotor type feeder.
64. Describe the design schemes and the principle of operation of rotary feeders.
65. Analyze the features of the design of the rotary feeder to move heavy products.
66. Describe the design and principle of operation of electromagnetic vibration feeders.
67. Describe the design and principle of operation of feeders of combined type.
68. Analyze what signs can be classified liquid products as an object of packaging?
69. Analyze the classification and main characteristics of the dosage process of liquid products.
70. Analyze the types of containers in which liquid products are packaged?
71. Describe devices for barometric isobaric packaging.
72. Analyze the design and principle of operation of devices with measuring cups and valve system.
73. Analyze what is the method of calculating the packaging devices of liquid products?
74. Describe the hydraulic circuits of dosing and packing devices of liquid products.
75. Describe ways to determine the coefficient of pressure loss of dosing and packing devices of liquid products.
76. Analyze what signs can be classified as an object of packaging?
77. Analyze what types and types of packaging pack knitted products?

78. *Analyze the types of dispensers used to dosage viscous products?*
79. *Analyze the signs by which the dosing and packing devices of viscous products are classified?*
80. *Describe the typical design scheme of the membrane dispenser.*
81. *Describe the typical design scheme of the piston dispenser.*
82. *Analyze the method of technological calculation of dosing devices for viscous piston products.*
83. *Analyze what structural and mechanical parameters can characterize plastic products?*
84. *Analyze what signs can classify plastic products as an object of packaging?*
85. *Analyze what signs classify dosing and packing devices of plastic products?*
86. *Analyze the formulation of the linear problem of stationary thermal conductivity of the isotropic material.*
87. *Describe the formulation of the problem of static elasticity.*
88. *Analyze the mathematical formulation of the nonlinear problem of nonstationary thermal conductivity.*
89. *Describe the formulation of the problem of dynamic elasticity, taking into account large deformations.*
90. *Describe the formulation of a nonlinear nonstationary thermoelectric problem for isotropic material.*
91. *Describe the formulation of a related problem of thermal elasticity.*
92. *Analyze the formulation of the heat-hydrodynamics problem during the laminar flow of the incompressible Newtonian fluid.*
93. *Analyze the formulation of the heat-hydrodynamics problem during the turbulent flow of incompressible Newtonian fluid based on the standard $k - \varepsilon$ model.*
94. *Describe the physical equations for non-Newtonian fluids.*
95. *Describe the main models of dilatant (composite) substances.*
96. *Describe the formulation of the problem of the heat-hydrodynamic state of the composite liquid of the type Bingham-Papanastasiou.*
97. *Analyze the mathematical model of the process of impregnating torn media during the manufacture of composite containers.*
98. *Analyze what is the main difference between discrete and continuum representations of the movement of the environment?*
99. *Analyze the formulation of the problem of a moving layer of bulk material using MDE.*

The working program of the educational component (syllabus):

Compiled by Professor, Doctor of Technical Sciences, Professor, Anton KARVATSKYI

Approved By the Department of Chemical, Polymer and Silicate Mechanical Engineering (Minutes No. 17 dated 04.06.2025)

Agreed By the Methodological Commission of the Faculty (Minutes No. 11 dated 06.27.2025)