



Educational component of the 6th F-Catalog Rheology
Work program of the educational component (Syllabus)

Details of the educational component

Higher education level	<i>First (bachelor's)</i>
Field of Knowledge	<i>13 Mechanical Engineering</i>
Speciality	<i>131 Applied Mechanics</i>
Educational program	<i>OPP Packaging and Packaging Equipment Engineering</i>
Status of the educational component	<i>Custom</i>
Form of study	<i>full-time (full-time)</i>
Year of preparation, semester	<i>3rd year, spring semester</i>
Scope of the educational component	<i>4(120)</i>
Semester control / control measures	<i>Passed</i>
Class schedule	<i>3 hours per week (1 hour of lectures, 1 hour of laboratory and 1 hour of practical classes)</i>
Language of instruction	<i>Ukrainian</i>
Information about the course leader / teachers	<i>Lecturer: Associate Professor, Doctor of Technical Sciences, Sokolsky Oleksandr, https://cpsm.kpi.ua/sokolskij-oleksandr-leonidovich.html?tmpl=component Practical /seminar/ laboratory: Assistant, PhD., Gerasymenko Yuliia</i>
Course placement	<i>Sikorsky Platform</i>

Program of the educational component

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

The syllabus of the educational component "Rheology" is compiled in accordance with the educational program for training bachelors of specialty 131 – Applied Mechanics under the educational program "Engineering of Packaging and Packaging Equipment".

The educational component belongs to the cycle of Selective Educational Components.

The subject of the educational component *is the laws of state and movement of media with rheologically complex properties, their experimental definition and use in the calculations of technological equipment and processes.*

The purpose of the educational component "Rheology"

The purpose of the educational component is to form students' competencies.

Integral competence: The ability to solve complex specialized problems and practical problems in applied mechanics or in the learning process, which involves the application of certain theories and methods of mechanical engineering and is characterized by complexity and uncertainty of conditions.

- *Knowledge and understanding of the subject area and understanding of professional activities (GC2);*
- *Ability to identify, pose and solve problems (GC3);*
- *Ability to apply knowledge in practical situations (GC4).*

And:

- Ability to analyze materials, structures and processes based on laws, theories and methods of mathematics, natural sciences and applied mechanics (FC1);
- Ability to perform technical measurements, obtain, analyze and critically evaluate measurement results (FC6).

After mastering the educational component, students must demonstrate the following programmatic learning outcomes:

knowledge:

- know and understand related fields (mechanics of liquids and gases, heat engineering, electrical engineering, electronics) and be able to identify interdisciplinary connections of applied mechanics at the level necessary to fulfill other requirements of the educational program (PH9);
- know the designs, methods of selection and calculation, the basics of maintenance and operation of drives of machine and robotic equipment (PH10).

Skill:

- choose and apply suitable mathematical methods (PH1) for solving problems of applied mechanics;
- to use knowledge of the theoretical foundations of the mechanics of liquids and gases, heat engineering and electrical engineering to solve professional problems (PH2)

2. Pre-requisites and post-requisites of the educational component (place in the structural and logical scheme of education according to the relevant educational program)

Interdisciplinary relations: the educational component "Rheology" is preceded by educational components, such as: "Physics", "Materials Science", "Resistance of Materials", "Mechanics of Liquid and Gas", "Mechanics of a Solid Deformed Body". The educational component provides educational components: "Packaging technologies and equipment" for the educational level "bachelor".

3. Content of the educational component

Topic 1. Tension.

Stress tensor. Cauchy's law. Tensor invariants.

Topic 2. Deformation.

Deformation tensor. Deformation under simple shear and uniaxial tension. Deformation rate. Genki deformity..

Topic 3. Classification of liquids.

Classification of liquids by flow curves. Flow index. Consistency coefficient.

Topic 4. Newtonian fluid flow

Newton's law. The flow curve of such a liquid. Determination of viscosity along a flow curve Stress graphs - time in constant flow velocity mode and in constant stress mode. Plots of shear velocity stresses in a cylindrical channel. Stresses and shear rates on the channel wall.

Topic 5. Flow of a stepping fluid

Exponential law. The flow of a degree fluid. Viscous flow activation energy.

Topic 6. Temperature dependence of viscosity

Determination of viscosity dependence on temperature.

Topic 7. Maxwell's model

Maxwell's model. The process of stress relaxation.

Topic 8. The Kelvin-Voigt model

The Kelvin-Voigt model. Retardation period. Recovery process.

Topic 9. Models of plastic materials

Saint-Venant's model. Complex elastic-plastic model of Shedov. Highly elastic deformation. Bingham's viscoplastic fluid.

Topic 10. Laws of viscosity dependence

Laws of dependence of viscosity on shear velocity Byrd-Carro, Hersley-Bulkley, Carro-Yasuda.

4. Training materials and resources

Basic literature

1. Rheology: Lecture Notes [Electronic resource] : nauch. Manual. for students. specialty 133 "Industrial Engineering", educational program "Engineering of equipment for the production of polymer and building materials and products" / KPI. Igor Sikorsky; compiled by: I. I. Ivitsky. Electronic text data. – Kyiv: KPI. Igor Sikorsky, 2019. – 88 p. <https://ela.kpi.ua/handle/123456789/26729>

2. Rheology: Practicum [Electronic resource] : nauch. Manual. for students. specialty 133 "Industrial Engineering", educational program "Engineering of equipment for the production of polymer and building materials and products" / KPI. Igor Sikorsky; compiled by I. I. Ivitskyi, I. O. Mikulonok. Electronic text data. – Kyiv: KPI. Igor Sikorsky, 2019. – 35 p. <https://ela.kpi.ua/handle/123456789/27998>

3. Rheology: Laboratory Practicum [Electronic resource] : study. Manual. for students. specialty 133 "Industrial Engineering", educational program "Engineering of equipment for the production of polymer and building materials and products" / KPI. Igor Sikorsky; compiled by I. I. Ivitskyi, I. O. Mikulonok. Electronic text data. – Kyiv: KPI. Igor Sikorsky, 2019. – 23 p. <https://ela.kpi.ua/handle/123456789/27508>

Information resources on the Internet

1. Electronic archive of KPI
2. Website of the Department of Chemical Engineering, <http://cpsm.kpi.ua/mr.html>
3. Campus of KPI. Igor Sikorsky, <http://login.kpi.ua/>

Educational content

5. Methods of mastering the educational component

Lectures

Lectures are aimed at providing modern, holistic knowledge in the field of rheology; ensuring the creative work of students together with the teacher during the lecture; formation of students' necessary interest and provision of direction for independent work; acquisition of visual information, combination, if possible, with the demonstration of audiovisual materials, models, models and samples; teaching in clear and clear language, explaining all newly introduced terms and concepts.

No. s/p	Title of the topic of the lecture and a list of main questions (list of didactic tools, references to literature and tasks on the SRS)	Hours
1	Topic 1. Tension Stress tensor. Cauchy's law. Tensor invariants. References: [1-3]. Tasks on CPS: Tensor and stress deviator.	2
2	Topic 2. Deformation Deformation tensor. Deformation under simple shear and uniaxial tension. Deformation rate. Genki deformity. References: [1-3]. Tasks on the SRS: Tensor and deformation deviator.	2
3	Topic 3. Classification of liquids Classification of liquids by flow curves. Flow index. Consistency coefficient. References: [1-3]. Tasks on the CPS: Calculation of the flow index and consistency coefficient.	2
4	Topic 4. Newtonian fluid flow Newton's law. Flow curve of a viscous liquid. Determination of viscosity along the flow curve. Stress graphs - time in constant flow speed mode and in constant stress mode. Plots of shear velocity stresses in a cylindrical channel. Stresses and shear rates on the channel wall. References: [1-3].	2

	<i>Task on SRS: Newton's Law in Tensor Form. Leak in the pipe. Flow in the annular gap.</i>	
5	Topic 5. Flow of a stepping fluid <i>Exponential law. The flow of a degree fluid. Viscous flow activation energy. References: [1-3].</i> <i>Task on CPS: Calculation of activation energy.</i>	2
6	Topic 6. Temperature dependence of viscosity <i>Determination of viscosity dependence on temperature. References: [1-3].</i> <i>Tasks on SRS: Methods for determining the temperature dependence of viscosity.</i>	2
7	Topic 7. Maxwell and Kelvin-Voigt models <i>Maxwell's model. The process of stress relaxation. The Kelvin-Voigt model. Retardation period. Recovery process. References: [1-3].</i> <i>Tasks on SRS: Relaxation period.</i>	2
8	Topic 8. Models of plastic materials <i>Saint-Venant's model. Complex elastic-plastic model of Shvedov. Highly elastic deformation. Bingham's viscoplastic fluid. References: [1-3].</i> <i>Tasks on the CPS: Cold hood of the Shvedov model.</i>	2
9	Topic 9. Laws of viscosity dependence <i>Laws of dependence of viscosity on shear velocity Byrd-Carro, Hersley-Bulkley, Carro-Yasuda. References: [1-3].</i> <i>Tasks on the SRS: A method for determining the law that optimally describes the behavior of the material.</i>	2
	Just	18

Practical classes

The main purpose of practical classes on the educational component is to consolidate theoretical knowledge and form skills in the study of the flow of polymer and composite materials.

No. s/p	Title of the topic of the practical lesson and a list of main questions (list of didactic support, references to literature and tasks on the SRS)	Hours
1	<i>Practical lesson 1. Mathematical processing of the "stress - strain" diagram. References: [1-3].</i> <i>Tasks on the SRS: Performing the calculation according to an individual task.</i>	2
2	<i>Practical lesson 2. The flow of the stepping fluid in the pipe. References: [1-3].</i> <i>Tasks on the SRS: Performing the calculation according to an individual task.</i>	2
3	<i>Practical lesson 3. The flow of a degree fluid in an annular gap. References: [1-3].</i> <i>Tasks on the SRS: Performing the calculation according to an individual task.</i>	2
4	<i>Practical lesson 4. Mathematical processing of the temperature dependence of viscosity and determination of rheological parameters of the material. References: [1-3].</i> <i>Tasks on the SRS: Performing the calculation according to an individual task.</i>	2
5	<i>Practical lesson 5. Determination of the law of dependence of viscosity on shear velocity, which optimally describes the behavior of the material. References: [1-3].</i> <i>Tasks on the SRS: Performing the calculation according to an individual task.</i>	2

6	<i>Practical lesson 6. Determination of the value of viscosity from the shear velocity according to the Byord-Carro Carro-Yasuda law.</i>	2
7	<i>Practical lesson 7. Determination of the Viscosity Value from the Shear Rate by the Hersley-Bulkley Law</i>	2
8	<i>Practical lesson 8. Determination of the Viscosity Value from the Shear Velocity by the Carro-Yasuda Law</i>	2
9	<i>Colloquium on the defense and acceptance of practical works</i>	2
	Just	18

Laboratory classes

The purpose of the cycle of laboratory work on the credit module is to consolidate theoretical knowledge, form the ability to determine the rheological and physical-mechanical properties of polymer and composite materials.

No. s/p	Title of the topic of the laboratory lesson and a list of main questions (list of didactic support, references to literature and tasks for the SRS)	Hours
1	<i>Briefing on safety and familiarization of students with the program of laboratory work and laboratory equipment.</i>	2
2	<i>Laboratory work 1. Determination of the viscosity of liquids on a capillary viscometer. References: [1-3]. Tasks for SRS: Preparation and study of the protocol for laboratory work.</i>	2
3	<i>Laboratory work 2. Determination of the dependence of the viscosity of liquids on the shear rate. References: [1-3]. Tasks for SRS: Preparation and study of the protocol for laboratory work.</i>	2
4	<i>Laboratory work 3. Determination of the dependence of the viscosity of polymeric materials on shear rate and temperature. References: [1-3]. Tasks for SRS: Preparation and study of the protocol for laboratory work.</i>	2
5	<i>Laboratory work 4. Study of the rheological properties of polyethylene. References: [1-3]. Tasks for SRS: Preparation and study of the protocol for laboratory work.</i>	2
6	<i>Laboratory work 5. Study of the rheological properties of polystyrene. References: [1-3]. Tasks for SRS: Preparation and study of the protocol for laboratory work.</i>	2
7	<i>Laboratory work 6. Determination of the viscosity of polymeric materials on a rotary viscometer. References: [1-3]. Tasks for SRS: Preparation and study of the protocol for laboratory work.</i>	2
8	<i>Colloquium on the reception and defense of laboratory work.</i>	2
9	<i>Modular control work</i>	2
	Just	18

6. Independent work of a student/postgraduate student

The main task of students' independent work is to master the issues that are not included in the list of lectures, through personal search for information, the formation of an active interest in a creative approach in educational work. In the process of independent work within the framework of the educational component, the student must learn to deeply analyze the task and, based on the analysis of the information received, come to his own reasonable conclusions.

No. s/p	Name of the topic submitted for independent study	Number of CPC hours
1	Topic 1. Tension References: [1-3]. Tasks on CPS: Tensor and stress deviator.	6
2	Topic 2. Deformation References: [1-3]. Tasks on the SRS: Tensor and deformation deviator.	6
3	Topic 3. Classification of liquids References: [1-3]. Tasks on the CPS: Calculation of the flow index and consistency coefficient.	6
4	Topic 4. Newtonian fluid flow References: [1-3]. Task on SRS: Newton's Law in Tensor Form. Leak in the pipe. Flow in the annular gap.	6
5	Topic 5. Flow of a stepping fluid References: [1-3]. Task on CPS: Calculation of activation energy.	6
6	Topic 6. Temperature dependence of viscosity References: [1-3]. Tasks on SRS: Methods for determining the temperature dependence of viscosity.	6
7	Topic 7. Maxwell and Kelvin-Voigt models References: [1-3]. Tasks on SRS: Relaxation period.	6
8	Topic 8. Models of plastic materials References: [1-3]. Tasks on the SRS: Cold hood of the Shedov model.	6
9	Topic 9. Laws of viscosity dependence References: [1-3]. Tasks on the SRS: A method for determining the law that optimally describes the behavior of the material.	8
10	Preparation for the MCR	4
11	Preparation for the test	6
	Total hours	66

7. Individual lessons

Individual tasks are not provided for in the work curriculum.

Policy and control

8. Educational Component Policy

Rules for attending classes and behavior in the classroom

Attendance at classes is a mandatory component of assessment. Applicants 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's conduct, not to be distracted by actions not related to the educational process.

Rules for assigning incentive and penalty points

Incentive points are not provided within the educational component

Penalty points (1 for each violation) are issued for:

- lack of admission to laboratory work due to unsatisfactory incoming control;*
- absence from the laboratory lesson without a valid reason;*
- untimely (later than at the control lesson) delivery of laboratory work*

Deadline and retake policy

In case of debts from the educational component or any force majeure circumstances, applicants should contact the teacher through the available (provided by the teacher) communication channels to solve problematic issues and agree on an algorithm of actions for working out.

Academic Integrity Policy

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism includes the absence of references when using printed and electronic materials, quotes, opinions of other authors. Hints and cheating are unacceptable when writing tests, conducting classes; passing the test for another applicant; 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 Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: <https://kpi.ua/code>

Academic Conduct and Ethics Policy

Applicants should be tolerant, respect the opinion of others, formulate objections in the correct form, and constructively support 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". Read more: <https://kpi.ua/code>

9. Types of control and rating system for assessing learning outcomes (ALO)

Distribution of study time by types of classes and tasks from the educational component according to the curriculum:

Semester	Study time		Distribution of training hours				Control measures		
	Loans	Acad. H.	Lecture	Prakt	Labor e	SRS	MCW	RR	Semester control
6	4	120	18	18	18	66	1	–	Passed

The student's rating in the educational component consists of the points that he receives for work in practical classes, laboratory work and the performance of modular control work.

Semester control is a test.

System of rating (weight) points and evaluation criteria

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

- 1) performance and defense of 8 practical works;*
- 2) Performance and defense of 6 laboratory works*
- 3) performance of tasks at the MCR;*

System of rating (weight) points and evaluation criteria

Completing tasks in practical classes.

The weight score for performing practical work is 6 points each. The maximum number of points in all practical classes is $6 \times 8 = 48$ points.

Criteria for evaluating the performance of practical work

Completeness and signs of work completion	Points
<i>The work was done in full</i>	<i>6</i>
<i>Untimely completion of work, minor shortcomings</i>	<i>5-4</i>
<i>Poor quality work</i>	<i>3</i>
<i>Failure to do work</i>	<i>0</i>

Completing tasks in laboratory classes.

The weight score of laboratory work is 6 points each. The maximum number of points in all laboratory classes is $6 \times 6 = 36$ points.

Criteria for evaluating the performance of laboratory work

Completeness and signs of work completion	Points
<i>The work was done in full</i>	<i>6</i>
<i>Untimely completion of work, minor shortcomings</i>	<i>5-4</i>
<i>Poor quality work</i>	<i>3</i>
<i>Failure to do work</i>	<i>0</i>

Performing a modular control.

The weight score of the MCW performance is 16 points.

The MCW consists of two questions of 8 points each.

Criteria for evaluating the implementation of the ICR

Completeness and signs of task completion	Points
<i>The task was completed in full</i>	<i>8</i>
<i>Minor deficiencies in paragraph 1</i>	<i>7</i>
<i>Significant deficiencies in paragraph 1</i>	<i>6</i>
<i>Incomplete completion of the task</i>	<i>5</i>
<i>Failure to complete the task</i>	<i>0</i>

Incentive points are not provided.

Penalty points are given for:

- lack of admission to laboratory work due to unsatisfactory incoming control – 1 point;*
- absence from a laboratory lesson without a valid reason – 1 point;*
- untimely (later than at the control lesson) delivery of laboratory work – 1 point.*

The total number of penalty points cannot exceed 10 (10% of the starting component).

The maximum amount of points is 100. A prerequisite for admission to the test is the enrollment of all laboratory work and practical work and the starting component of the rating is at least 24 points (40% of the maximum sum of points of the starting component).

According to the results of educational work for the first 7 weeks, the "ideal student" should score 20 points. At the attestation (8th week), the student receives "enrolled" if his current rating is at least 10 points.

According to the results of 15 weeks, the "ideal student" should score 40 points. At the second attestation (14th week), the student receives "enrolled" if his current rating is at least 20 points.

Thus, the rating semester scale from the educational component is:

$$R = 48 + 36 + 16 = 100 \text{ points}$$

To receive a test from the educational component "automatically", you need to have a rating of at least 60 points.

*Students who score on the grade scale of **F** (40 points or less) are not allowed to take the test and must increase their rating.*

Students who received 41-59 points (**Fx grade**), or those who want to increase their grade, perform a test. At the same time, the points scored during the semester are canceled.

On the test, students perform a written test work. Each task contains two theoretical questions. The list of questions is given in paragraph 10 of the syllabus of the educational component. Each theoretical question is evaluated at 50 points.

Question evaluation system:

- "excellent", complete answer (at least 95% of the required information) – 48-50 points;
- "good", a sufficiently complete answer (at least 75% of the necessary information or minor inaccuracies) – 38-47 points;
- "satisfactory", incomplete answer (at least 60% of the required information and some errors) – 30-37 points;
- "unsatisfactory", unsatisfactory answer – 0 points.

The maximum rating of the test is

$$RE = RT1 + RT2 = 50 + 50 = 100 \text{ points.}$$

Conditions for admission to semester control: enrollment of all laboratory work and practical work and the starting component of the semester rating is at least 20 points.

To obtain the final grade, the sum of all rating points R received during the semester is converted according to the table:

Score	Score
95...100	Perfectly
85...94	Very good
75...84	well
65...74	Satisfactory
60...64	enough
RD < 60	Disappointing
Not met the conditions of admission	not allowed

10. Additional information on the educational component

Approximate list of questions submitted for semester control

1. Describe the ratio of transverse to longitudinal deformation for incompressible volume elements. Recording and output.
2. Describe the distribution of shear velocities with a constant flow of Newtonian fluid in a cylindrical channel.
3. Describe the distribution of shear velocities with a constant flow of steppe fluid in a cylindrical channel.
4. Describe the velocity distribution of a Newtonian fluid when flowing in a cylindrical channel.
5. Describe the distribution of velocities during the flow of steppe fluid in a cylindrical channel.
6. Give the definition, derivation and application of the correction that takes into account the increase in the shear rate on the channel wall for stepping fluids.
7. Give a calculation of the dissipative increase in temperature at the tangential flow of a Newtonian fluid in a cylinder-cylinder gap.
8. Calculate the power of the rotor drive at the tangential flow of the Newtonian fluid in the cylinder-cylinder gap.
9. Calculate the dissipative increase in temperature at the tangential flow of the stepper fluid in the cylinder-cylinder gap.
10. Calculate the power of the rotor drive at the tangential flow of the stepper fluid in the cylinder-cylinder gap.

11. Give the optimal method for approximating the dependence of viscosity on temperature and its equation.
12. Give a method for calculating the activation energy of a viscous flow for a steppe fluid.
13. Give a method for determining the relaxation period during deformation by the graphic method.
14. Give a method for determining the relaxation period during deformation by the analytical method.
15. Give a method for determining the retardation period during deformation by the graphical method.
16. Give a method for determining the retardation period during deformation by the analytical method.
17. Describe the application of the tribometer in rheological models of liquids. Its characteristics, features and models in which it is used.
18. Give a classification of the behavior of an elastic-plastic body in the regime of constant strain rates.
19. Classify fluids by flow curves.
20. Give a technique for determining the flow rate of fluid on the canal wall using capillary viscosymmetry.
21. Give a method for determining the rheological parameters of liquids in a capillary viscometer.
22. Give a method for determining the rheological parameters of liquids in a rotary viscometer.
23. Give stress graphs - time in constant flow speed mode and in constant stress mode.
24. Define tensor invariants.
25. Describe the longitudinal pressure gradient in stationary flow.
26. Describe the modulus of elasticity at shear and Young's modulus.
27. Describe simple displacement and uniaxial stretching.
28. Describe the nature of the deformation of an elastic body.
29. Give the calculation of the stress and shear rate on the channel wall.
30. Define the dissipation of mechanical energy.

List of questions for modular test work

1. Define the concept of stress.
2. Define the concept of stress tensor.
3. Describe the flow of a Newtonian fluid in a cylindrical channel.
4. Define the strain tensor.
5. Define tensor invariants.
6. Define the stress tensor deviator.
7. Define the Newtonian fluid.
8. Calculate the speed of deformation.
9. Describe the nature of the deformation of an elastic body.
10. Give a method for constructing a velocity plot.
11. Give Newton's law in tensor form.
12. Give Cauchy's law.
13. Define the stress tensor deviator.
14. Define the Genki deformation
15. Give stress graphs - time in constant flow speed mode and in constant stress mode.
16. Define tensor invariants.
17. Describe the longitudinal pressure gradient in stationary flow.
18. Describe the modulus of elasticity at shear and Young's modulus.
19. Describe simple displacement and uniaxial stretching.
20. Describe the nature of the deformation of an elastic body.
21. Give the calculation of the stress and shear rate on the channel wall.
22. Give a method for constructing a velocity plot.
23. Describe the dissipation of mechanical energy.
24. Define the concept of a stress tensor deviator.
25. Define the concept of Newtonian fluid.
26. Define the concept of a perfectly elastic body.

27. Describe the flow of fluid in a cylinder-cylinder and cone-plane gap.
28. Give Hooke's law in tensor form.
29. Describe the dissipation of mechanical energy.
30. Give the calculation of the stress and shear rate on the channel wall.

Work program of the educational component (syllabus):

Compiled by Assoc. Prof., Doctor of Technical Sciences, Sokolsky O.L.

Approved by the Department of CPSM (Prot. No. 17 of 04.06.2025)

Approved by the Methodological Commission of the Faculty of Engineering and Chemistry
(Prot. No. 11 dated 27.06.2025)