



Rheology

Work program of the educational component (Syllabus)

Details of the educational component

Higher education level	First (bachelor's)
Field of Knowledge	13 Mechanical Engineering
Speciality	133 Industrial Engineering
Educational program	OPP Engineering of equipment for the production of polymer and building materials and products
Status of the educational component	Mandatory
Form of study	full-time (full-time)
Year of preparation, semester	3rd year, spring semester
Scope of the educational component	4(120)
Semester control / control measures	Exam
Class schedule	3 hours per week (1 hour of lectures, 1 hour of laboratory and 1 hour of practical classes)
Language of instruction	Ukrainian
Information about the course leader / teachers	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
Course placement	Sikorsky Platform

Program of the educational component

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

The syllabus "Rheology" is compiled in accordance with the educational program for training bachelors of specialty 133 – Industrial Engineering under the educational program "Engineering of equipment for the production of polymer and building materials and products".

The educational component "Rheology" belongs to the cycle of professional training (mandatory 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 of a person to solve complex specialized tasks and practical problems in a certain field of professional activity or in the process of learning, which involves the application of certain theories and methods of the relevant sciences and is characterized by complexity and uncertainty of conditions.

- Ability to apply rheological laws for calculating the parameters of technological processes (FC 14).

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

knowledge:

- Knowledge and understanding of the principles of technological, fundamental and engineering sciences that underlie the industrial engineering of the relevant industry (PH 1);
- Knowledge and understanding of mechanics and mechanical engineering and prospects for their development (PH 2);
- Understand the appropriate methods and have the skills to design typical units and mechanisms in accordance with the task (PH 8);
- Know and understand the rheological features of the media used as raw materials and working media (PH 18).

Skill:

- Carry out engineering calculations to solve complex problems and practical problems in industrial engineering (PH 4);
- Analyze engineering objects, processes and methods (PH 5);
- Choose and apply the necessary equipment, tools and methods (PH 9).

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", "Applied Mechanics of a Solid Deformed Body". The educational component provides educational components: "Mechanical processes and equipment for the production of polymer and building materials and products".

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 Shvedov. 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] : 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. 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. 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.	2

	<i>References: [1-3].</i> <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.</i> <i>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.</i> <i>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.</i> <i>Retardation period. Recovery process.</i> <i>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.</i> <i>Highly elastic deformation. Bingham's viscoplastic fluid.</i> <i>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.</i> <i>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	Practical lesson 1. Mathematical processing of the "stress - strain" diagram. <i>References: [2].</i> <i>Tasks on the SRS: Performing the calculation according to an individual task.</i>	2
2	Practical lesson 2. The flow of the stepping fluid in the pipe. <i>References: [2].</i> <i>Tasks on the SRS: Performing the calculation according to an individual task.</i>	2
3	Practical lesson 3. The flow of a degree fluid in an annular gap. <i>References: [2].</i> <i>Tasks on the SRS: Performing the calculation according to an individual task.</i>	2
4	Practical lesson 4. Mathematical processing of the temperature dependence of viscosity and determination of rheological parameters of the material. <i>References: [2].</i> <i>Tasks on the SRS: Performing the calculation according to an individual task.</i>	2
5	Practical lesson 5. Determination of the law of dependence of viscosity on shear velocity, which optimally describes the behavior of the material.	2

	<i>References: [2]. Tasks on the SRS: Performing the calculation according to an individual task.</i>	
6	<i>Practical lesson 6. Determination of the value of viscosity from the shear velocity according to the Byord-Carro Carro-Yasuda law. References: [2]. Tasks on the SRS: Performing the calculation according to an individual task.</i>	2
7	<i>Practical lesson 7. Determination of the Viscosity Value from the Shear Rate by the Hersley-Bulkley Law References: [2]. Tasks on the SRS: Performing the calculation according to an individual task.</i>	2
8	<i>Practical lesson 8. Determination of the Viscosity Value from the Shear Velocity by the Carro-Yasuda Law References: [2]. Tasks on the SRS: Performing the calculation according to an individual task.</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 educational component is to consolidate theoretical knowledge, form the ability to determine the rheological and physical-mechanical properties of polymeric 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: [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: [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: [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: [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: [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: [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.	2
2	Topic 2. Deformation References: [base 6, supplement 4]. Tasks on the SRS: Tensor and deformation deviator.	4
3	Topic 3. Classification of liquids References: [1-3]. Tasks on the CPS: Calculation of the flow index and consistency coefficient.	3
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.	3
5	Topic 5. Flow of a stepping fluid References: [1-3]. Task on CPS: Calculation of activation energy.	4
6	Topic 6. Temperature dependence of viscosity References: [1-3]. Tasks on SRS: Methods for determining the temperature dependence of viscosity.	3
7	Topic 7. Maxwell and Kelvin-Voigt models References: [1-3]. Tasks on SRS: Relaxation period.	4
8	Topic 8. Models of plastic materials References: [1-3]. Tasks on the SRS: Cold hood of the Shedov model.	3
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.	6
	Preparation for the MCR	4
9	Exam preparation	30
	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	–	Exam

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

Semester control is an exam.

System of rating (weight) points and evaluation criteria

The student's rating in the educational component 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 MCW;*
- 4) *passing the exam.*

System of rating (weight) points and evaluation criteria

Completing tasks in practical classes.

The weight score for performing practical work is 3 points each.

Criteria for evaluating the performance of practical work

Completeness and signs of work completion	Points
<i>The work was done in full</i>	<i>3</i>
<i>Untimely completion of work, minor shortcomings</i>	<i>2</i>
<i>Poor quality work</i>	<i>1</i>
<i>Failure to do work</i>	<i>0</i>

Completing tasks in laboratory classes.

The weight score of laboratory work is 3 points each.

Criteria for evaluating the performance of laboratory work

Completeness and signs of work completion	Points
<i>The work was done in full</i>	<i>3</i>
<i>Untimely completion of work, minor shortcomings</i>	<i>2</i>
<i>Poor quality work</i>	<i>1</i>
<i>Failure to do work</i>	<i>0</i>

Performing a modular control.

The weight score of the MCW performance is 8 points.

Criteria for evaluating the implementation of the ICR

Completeness and signs of task completion	Points
<i>The MCR is 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>

Conditions for admission to semester control: minimum positive assessment for laboratory and practical work 13 points.

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).

Semester control: exam.

The weight score of the exam work is 50 points. The ticket contains two questions of 25 points each.

Criteria for evaluating the performance of the exam work

Completeness and signs of task completion	Points
<i>The work is done in full</i>	<i>25</i>
<i>Minor deficiencies in paragraph 1</i>	<i>24-22</i>
<i>Significant deficiencies in paragraph 1</i>	<i>21-19</i>
<i>Incomplete completion of the task</i>	<i>18-15</i>
<i>Failure to complete the task</i>	<i>0</i>

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

$$R = 24 + 18 + 8 + 50 = 100 \text{ points}$$

According to the results of educational work for the first 7 weeks, the "ideal student" should score 16 points. At the first attestation (8th week), the student receives "enrolled" if his current rating is at least 10 points.

According to the results of educational work for 13 weeks of study, the "ideal student" should score 32 points. At the second attestation (14th week), the student receives "enrolled" if his current rating is at least 20 points.

The maximum amount of points is 100.

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

- Describe the ratio of transverse to longitudinal deformation for incompressible volume elements. Recording and output.
- Describe the distribution of shear velocities with a constant flow of Newtonian fluid in a cylindrical channel.
- Describe the distribution of shear velocities with a constant flow of steppe fluid in a cylindrical channel.
- Describe the velocity distribution of a Newtonian fluid when flowing in a cylindrical channel.
- Describe the distribution of velocities during the flow of steppe fluid in a cylindrical channel.
- 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.
- Give a calculation of the dissipative increase in temperature at the tangential flow of a Newtonian fluid in a cylinder-cylinder gap.
- Calculate the power of the rotor drive at the tangential flow of the Newtonian fluid in the cylinder-cylinder gap.
- Calculate the dissipative increase in temperature at the tangential flow of the stepper fluid in the cylinder-cylinder gap.
- Calculate the power of the rotor drive at the tangential flow of the stepper fluid in the cylinder-cylinder gap.
- Give the optimal method for approximating the dependence of viscosity on temperature and its equation.
- Give a method for calculating the activation energy of a viscous flow for a steppe fluid.
- Give a method for determining the relaxation period during deformation by the graphic method.
- Give a method for determining the relaxation period during deformation by the analytical method.
- Give a method for determining the retardation period during deformation by the graphical method.
- Give a method for determining the retardation period during deformation by the analytical method.
- Describe the application of the tribometer in rheological models of liquids. Its characteristics, features and models in which it is used.
- 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)