STUDY MODULE DESCRIPTION FORM

Name of the module/subject	Code
Technical Rheology	

Field of study	Profile of study (general academic, practical)	Year /Semester
Chemical and Process Engineering	**general academic**	**3/5**
Elective path/specialty	Subject offered in:	Course (compulsory, elective)
-	**Polish**	**obligatory**

Cycle of study:	Form of study (full-time,part-time)
First-cycle studies	**full-time**

No. of hours	No. of credits
Lecture: **30** Classes: **-** Laboratory: **30** Project/seminars: **-**	**5**

Status of the course in the study program (Basic, major, other)	(university-wide, from another field)
basic	**university-wide**

Education areas and fields of science and art	ECTS distribution (number and %)
technical sciences	**5 100%**
technical sciences	**5 100%**

Responsible for subject:

Responsible for lecturer:

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Prerequisites in terms of knowledge, skills and social competencies:

1	**Knowledge**	The student knows: • basis of mathematical analysis, • basis of chemistry and physics
2	**Skills**	The student has the skills: • the use of spreadsheets, • statistical analysis of measurement results, • principles of technical drawings
3	**Social competencies**	The student knows the limitations of his knowledge and foresees the need for the dredging.

Assumptions and objectives of the course:

1. Getting students with the basic knowledge of technical rheology, in particular with properties of non-Newtonian fluids and their microstructure, rheometry and methods of calculation of pressure loss.
2. Development of ability of perform rheological study and practical use of the results obtained from experiment.

Study outcomes and reference to the educational results for a field of study

Knowledge:

1. The student knows the basic concepts of rheology: dynamic, kinematic and extensional viscosity, flow and viscosity curves, Deborah number, classification of fluids - [K_W11]
2. The student knows the basic rheological properties of time-independent and time dependent fluids, viscoelastic fluids, magneto- and electrorheological fluids and methods of their mathematical description - [K_W11]
3. The student knows the theoretical basis of capillary and rotational rheometry, measurement methods of viscoelastic properties of fluid and extensional viscosity, advantages and disadvantages of the different measurement methods and principles of their selection - [K_W11]
4. The student knows the basic rheological properties of polymeric fluids, two-phase systems, and biomaterials used in the chemical industry - [K_W09]
5. The student knows the methods of calculating the pressure loss for different classes of non-Newtonian fluids in pipelines - [K_W11], [K_W15]

Skills:

1. The student is able to select an appropriate measurement method for determining the rheological properties of the various fluids - [K_U08], [K_U18]
2. The student can perform rheological measurements using different methods - [K_U08], [K_U12]
3. The student is able to distinguish, based on the experimental studies, the rheological properties of various non-Newtonian fluids and to use appropriate mathematical rheological models to describe the flow curves - [K_U08]
4. The student is able to find relation between rheological properties of fluid and their application - [K_U07]

Social competencies:

1. The student understands the need to broaden their knowledge and skills due to the rapid advances in the chemical industry. He is aware that continuous training is a way to remain competitive in the labor market - [K_K01]
2. The student can independently and as a team perform various tasks. He is aware of the responsibility for their implementation within the team - [K_K04]

Assessment methods of study outcomes

Knowledge:
Point 1-5: Written exam (test and problem questions)
Skills:
Point 1-4: Written test and discussion about the realization of laboratory exercises
Point 3: Assessment of report from laboratory exercises
Social competencies:
Point 1 i 2: The report and discussion with students about the report and assessment by a group of involvement of individual team members.

Course description

The course covers the following topics:

1. The elastic, viscous and viscoelastic response
2. Time as an additional parameter in characterizing material response
3. Simple shear of solids and fluids
4. Kinematic viscosity and dynamic viscosity
5. Influence of temperature and pressure on the rheological properties of fluids
6. Non-Newtonian fluids: definition, the concept of a generalized Newtonian fluids, classification
7. Mathematical descriptions of flow curves of time-independent fluids
8. The interpretation of the phenomena of shear thickening and shear thinning
9. Yield stress fluids (microstructure and methods of determining yield stress)
10. Time-dependent fluids (thixotropy and anti-thixotropy)
11. First normal stress differences
12. Normal stress effects (Weissenberg effect, Barus effect)
13. Mechanical models of viscoelastic liquids (Maxwell, Kelvin, Burgers)
14. Magnetorheological and electrorheological fluids
15. Viscometric flows
16. Characteristics of viscometers (gravitational capillary viscometers, orifice viscometers, falling ball viscometers)
17. Single particle settling (falling velocity, the drag force on a spherical and non-spherical particle, Schiller-Naumann model, Kozioł model).
18. Capillary rheometry - basic equations.
19. Rotational rheometry - basic equations.
20. Measurement methods of viscoelastic fluid properties
21. Advantages and disadvantages of rheometers: capillary rheometers, concentric cylinders rheometers, cone-and-plate rheometers
22. Extensional viscosity – definition and measurement methods
23. Calculation of pressure drop of non-Newtonian fluid flow in channels
24. Drag reduction phenomenon
25. Rheological properties of polymeric fluids
26. Rheological properties of dispersed two-phase systems
27. Methods of estimating a shear rate

Basic bibliography:

1. M. Dziubiński, T. Kiljański, J. Sęk, Podstawy teoretyczne i metody pomiarowe reologii, Wydawnictwo Politechniki Łódzkiej, Łódź 2014.
2. M. Dziubiński, Kiljański T., Sęk J.: Podstawy reologii i reometrii płynów, Wydawnictwo Politechniki Łódzkiej, Łódź 2009.
3. T. Kiljański, M. Dziubiński, J. Sęk, K. Antosik: Wykorzystanie właściwości reologicznych płynów w praktyce inżynierskiej, Wydawca EKMA Krzysztof Antosik, Warszawa 2009.
4. K. Wilczyński: Reologia w przetwórstwie tworzyw sztucznych, Wydawnictwo Naukowo-Techniczne, Warszawa 2001.

Additional bibliography:

1. J. Ferguson, Z. Kembłowski: Reologia stosowana płynów, Wydawnictwo Marcus s.c., Łódź 1995.
2. Z. Kembłowski, T. Kiljański: Ćwiczenia laboratoryjne z reometrii technicznej, Wydawnictwo Politechniki Łódzkiej, Seria: Skrypty, Łódź 1993.
3. Z. Orzechowski, J. Prywer, R. Zarzycki: Mechanika płynów w inżynierii środowiska, WNT, Warszawa 1997.

Result of average student's workload

Activity	Time (working hours)
1. Preparation for exam	45
2. Exam	3
3. Preparation for tests	15
4. Preparation for laboratories, including the preparation of reports	12
5. Participation in laboratory exercises	30
6. Preparation of the report of the analysis of literature	10
7. Consultation	6

Student's workload		
Source of workload	**hours**	**ECTS**
Total workload	125	5
Contact hours	74	2,7
Practical activities	30	1,2