STUDY MODULE DESCRIPTION FORM

Name of the module/subject	Code
Applied Rheology	**1010702211010700346**

Field of study	Profile of study (general academic, practical)	Year /Semester
Chemical Technology	**general academic**	**1 / 1**
Elective path/specialty: **Composites and Nanomaterials**	Subject offered in: **Polish**	Course (compulsory, elective): **obligatory**
Cycle of study: **Second-cycle studies**	Form of study (full-time,part-time): **full-time**	
No. of hours: Lecture: **15** Classes: **-** Laboratory: **30** Project/seminars: **-**		No. of credits: **2**
Status of the course in the study program (Basic, major, other): **basic**	(university-wide, from another field): **university-wide**	
Education areas and fields of science and art: **technical sciences**; **Technical sciences**		ECTS distribution (number and %): **2 100%**; **2 100%**

Responsible for subject / lecturer:

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Prerequisites in terms of knowledge, skills and social competencies:

1	**Knowledge**	Knowledge The student knows: a) basis of mathematical analysis, b) basis of chemistry and physics
2	**Skills**	The student has the skills: 1. the use of spreadsheets, 2. statistical analysis of measurement results, 3. 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. Student knows the basic concepts of rheology: dynamic, kinematic and extensional viscosity, flow and viscosity curves, Deborah number, classification of fluids - [K_W11]
2. 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. 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. Student knows the basic rheological properties of polymeric fluids, two-phase systems, and biomaterials used in the chemical industry - [K_W09]
5. Student knows the methods of calculating the pressure loss for different classes of non-Newtonian fluids in pipelines and columns - [K_W11]

Skills:

1. Student is able to select an appropriate measurement method for determining the rheological properties of the various fluids - [K_U08; K_U18]
2. Student can perform rheological measurements using different methods - [K_U08; K_U12]
3. 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. 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 tests on problem questions

Skills:

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

Basic bibliography:

1. Chhabra R.P., Bubbles, drops and particles in non-Newtonian fluids, CRC Taylor and Francis, Boca Raton 2007.
2. Chhabra R.P., Richardson J.F., Non-Newtonian flow and applied Rheology, Elsevier, Amsterdam 2008.
3. Steffe, J.F. Daubert C.R., Bioprocessing pipelines: Rheology and analysis, Freeman Press, East Lansing 2006.
4. Steffe, J.F., Rheological methods in food proces engineering, Freeman Press, East Lansing 1996.

Additional bibliography:

1. M. Dziubiński, Kiljański T., Sęk J.: Podstawy reologii i reometrii płynów, Wydawnictwo Politechniki Łódzkiej, Łódź 2009.
2. T. Kiljański, M. Dziubiński, J. Sęk, K. Antosik: Wykorzystanie właściwości reologicznych płynów w praktyce inżynierskiej, Wydawca EKMA Krzysztof Antosik, Warszawa 2009.
3. K. Wilczyński: Reologia w przetwórstwie tworzyw sztucznych, Wydawnictwo Naukowo-Techniczne, Warszawa 2001.
4. Z. Kembłowski: Reometria płynów nienewtonowskich, Wydawnictwo Naukowo-Techniczne, Warszawa 1973.
5. A. Ławniczak, A. Mielecki: Ciecze elektro- i magnetoreologiczne oraz ich zastosowania w technice, Wydawnictwo Politechniki Poznańskiej, Poznań 1999
6. J. Ferguson, Z. Kembłowski: Reologia stosowana płynów, Wydawnictwo Marcus s.c., Łódź 1995.
7. Z. Kembłowski, T. Kiljański: Ćwiczenia laboratoryjne z reometrii technicznej, Wydawnictwo Politechniki Łódzkiej, Seria: Skrypty, Łódź 1993.
8. 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. Participation in lectures	15
2. Preparation for tests	10
3. Preparation for laboratories, including the preparation of reports	5
4. Participation in laboratory exercises	30

Student's workload

Source of workload	hours	ECTS
Total workload	60	2
Contact hours	45	0
Practical activities	25	0