| UČNI NAČRT PREDMETA / COURSE SYLLABUS | |
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| **Predmet:** | IZBRANA POGLAVJA IZ REOLOŠKIH LASTNOSTI IN STRUKTURE KOMPLEKSNIH TEKOČIN |
| **Course Title:** | SELECTED TOPICS IN RHEOLOGY AND STRUCTURE OF COMPEX FLUIDS |

| **Študijski program in stopnja<br>Study Programme and Level** | **Študijska smer<br>Study Field** | **Letnik<br>Academic Year** | **Semester<br>Semester** |
|---|---|---|---|
| **DR Kemijske znanosti, 3. stopnja** | **/** | **1.** | **1. in 2.** |
| **Doctoral programme in Chemical Sciences, 3rd Cycle** | **/** | **1st** | **1st and 2nd** |

**Vrsta predmeta / Course Type:** izbirni/Elective

**Univerzitetna koda predmeta / University Course Code:** KZ326

| **Predavanja<br>Lectures** | **Seminar<br>Seminar** | **Vaje<br>Tutorial** | **Klinične vaje<br>Work** | **Druge oblike študija** | **Samost. delo<br>Individual Work** | **ECTS** |
|---|---|---|---|---|---|---|
| **30** | **10** | **/** | **/** | **70** | **40** | **5** |

**Nosilec predmeta / Lecturer:** prof. dr. Igor Plazl/ Dr. Igor Plazl, Full Professor

**Jeziki / Languages:**

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| **Predavanja / Lectures:** | **slovenski / Slovenian** |
| **Vaje / Tutorial:** | **slovenski / Slovenian** |

**Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:**

Študent oziroma kandidat mora imeti predmet opredeljen kot študijsko obveznost.

**Prerequisites:**

The course has to assigned to the student

**Vsebina:**

- Sistemi kompleksnih tekočin: ne-Newtonske tekočine, večfazni in/ali kemijsko reakcijski tokovi pri različnih dimenzijskih in časovnih skalah.
- Mikrofluidika: prednosti uporabe mikrosistemov. Problemi modeliranja mikrosistemov dvo-faznih sistemov: določitev strižnih napetosti, »slip« na steni, površinska napetost.
- Koncept, razvoj in uporaba večnivojskega modeliranja. Dinamika posamezne kapljice/mehurčka, Pojavi večnivojskega prenosa.

**Content (Syllabus outline):**

- The complex fluid systems: non-Newtonian, multiphase, turbulent, and/or chemically reacting flows at different length and time scales.
- Microfluidics: the advantages of using microsystems. The problems of modeling microsystems with two-phase flow: determination of viscous shear stress, slip at the wall, surface tension.
- Development and implementation of multiscale computation techniques. Single Droplet/Bubble Dynamics, Multiscale Transfer Phenomena.

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| • Nekonvencionalna topila: ionske tekočine (IL), vodni dvo-fazni sistemi (ATPS), eutektične mešanice.<br>• Eksperimentalni pristopi k reometriji: zakonitosti merjenja, merilne tehnike in postopki za karakterizacijo reološko kompleksnih tekočin in pol-trdnih materialov. | • Non-conventional solvents: Ionic liquids (ILs), aqueous two-phase system (ATPS), eutectic mixtures.<br>• Experimental approaches to rheometry: the principles of measurement, measuring techniques and procedures for rheological characterization of complex liquids and semi-solid materials. |

**Temeljna literatura in viri / Readings:**

- Multiphase Lattice Boltzmann Methods: Theory and Application, Haibo Huang, Michael Sukop, Xiyun Lu, July 2015, Wiley-Blackwell.
- Nanoscale Energy Transport and Conversion: A Parallel Treatment of Electrons, Molecules, Phonons, and Photons (MIT-Pappalardo Series in Mechanical Engineering), Gang Chen, Oxford University Press; 1 edition, 2005.
- Advanced Transport Phenomena: fluid mechanics and convective trasport processes, L. Gary Leal, Cambridge University Press, 2007, 899 str.
- The Structure and Rheology of Complex Fluids", Larson, R.G., 1999, Oxford University Press, Oxford, 663 s(na voljo: UL FKKT, Katedra za kemijsko, bioekemijsko in ekološko inženirstvo)
- Rheology, Principles, Measurements and Applications, Macosco C. W., 1994, VCH Publishers, Inc., New York, 550 s (na voljo: UL FKKT, Katedra za kemijsko, bioekemijsko in ekološko inženirstvo).

| **Cilji in kompetence:** | **Objectives and Competences:** |
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| Cilj predmeta je nadgraditi obstoječe znanje na področju dinamike kompleksnih tekočin, mikrofluidike večfaznih tokov, koncept večnivojskega modeliranja in poglobiti poznavanja eksperimentalnih pristopov reološke karakterizacije strukturiranih tekočin. Pridobljena znanja študentu omogočajo samostojno raziskovalno delo na področju preučevanja toka kompleksnih sistemov in reoloških lastnosti kompleksnih tekočin in poltrdnih snovi. Študent pri predmetu pridobi specifične kompetence za razumevanje, načrtovanje in optimicacijo kompleksnih tokovnih sistemov. | Objective of the course is to upgrade the existing knowledge in the field of complex fluid flows, microfluidics of multiphase flows, multiscale modeling concept, and to deepen understanding of experimental approaches to rheological characterization of structured fluids. Acquired knowledge enables the student independent research work in the field of complex fluid systems and rheological properties of complex fluids and semi-solids. Students acquire the specific competences for ability to understand the basic principles, and to design and optimize the complex flow systems. |

| **Predvideni študijski rezultati:** | **Intended Learning Outcomes:** |
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| <u>Znanje in razumevanje</u><br>Študent pridobi znanja in razumevanje: mehanizmov transportnih pojavov pri dinamiki kompleksnih tekočin, s poudarkom na tokovnih režimih večfaznih tokov in medfazni površini; lastnosti | <u>Knowledge and Comprehension</u><br>Upon the successful completion of study obligations, the students will be able to understand the transport characteristics of multiphase fluids, with a special emphasis on the flow regimes defined by the phase interface |

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| nekonvencionalnih topil; večnivojskega modeliranja in reologije z reometrijo. | surface; to define the characteristics of non-conventional solvents; to develop a corresponding mathematical system based on multiscale modeling concept; and to gain knowledge about rheology with rheometry. |
| Uporaba<br>Student lahko teoretično opiše tok kompleksnih tekočin in napove hitrostne profile večfaznih tokov. | Application<br>Student can theoretically describe the flow of complex fluids and predict velocity profiles for multiphase flows. |
| Refleksija<br>Na osnovi pridobljenih teoretičnih znanj in praktičnih vaj, študentje pridobijo veščine za analizo procesov, ovrednotenje podatkov in prenos znanja v raziskovalni in/ali tehnološki proces. | Analysis<br>Student develops the ability to critically apply gained knowledge in solving complex theoretical and practical problems. |
| Prenosljive spretnosti<br>Uporaba različnih literaturnih virov (knjige, članki, elektronsko gradivo) omogoča zbiranje podatkov oziroma vrednotenje lastnih rezultatov in njihovo interpretacijo ter preverjanje pravilnosti. Hkrati se razvijajo sposobnosti za vključevanje v skupinsko delo, komunikacijo in pripravo pisnega materiala. | Skill-transference Ability<br>Identification and solving of problems. Experimental data collection, analysis and critical evaluation of results. The use of scientific literature, writing and presentation of reports. |

| **Metode poučevanja in učenja:** | **Learning and Teaching Methods:** |
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| Predavanja, konzultacije, projektno delo, seminarji. | Lectures, consultations, project work, seminars. |

| **Načini ocenjevanja:** | Delež (v %) / Weight (in %) | **Assessment:** |
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| Ustni in pisni izpit | **60%** | Written and oral examination. |
| Izdelava seminarja (projekt) z njegovo predstavitvijo in zagovorom. | **40%** | Written seminar and its presentation. |

**Reference nosilca / Lecturer's references:**

R. Ambrožič, **I. Plazl**. Development of an electrically responsive hydrogel for programmable *in situ* immobilization within a microfluidic device. *Soft Matter*, 2021, 17, 6751 – 6764, doi: 10.1039/d1sm00510c.

A. Hubman, **I. Plazl**, T. Urbič. Inertial focusing of neutrally buoyant particles in heterogenous suspensions. *J. Mol. Liq.,* 2021**, 328,** 115410, doi: 10.1016/j.molliq.2021.115410.

F. Strniša, T. Urbič, **I. Plazl**. A lattice Boltzmann study of 2D steady and unsteady flows around a confined cylinder. *Journal of the Brazilian Society of Mechanical Sciences and Engineering*, ISSN 1678-5878. [Print ed.], Feb. 2020, vol. 42, iss. 2, pp. 1-13.