1.	**Field of study**	**Biophysics**
2.	Faculty	Faculty of Science and Technology
3.	Academic year of entry	2021/2022 (winter term)
4.	Level of qualifications/degree	second-cycle studies
5.	Degree profile	general academic
6.	Mode of study	full-time

Module: Rheology

Module code: W4-2BF-MB-21-10

1. Number of the ECTS credits: 6

2. Learning outcomes of the module

code	description	learning outcomes of the programme	level of competence (scale 1-5)
MB_10_1	the student is aware of the importance of rheology in scientific research, industrial applications, and life including daily activities	KBF_W02 KBF_W04	4 5
MB_10_2	the student knows the main rheological behaviors of the materials and can recognize the rheological behaviour of different material	KBF_W10	5
MB_10_3	the student can apply the main rheological models	KBF_K02 KBF_U07 KBF_W04	4 4 4
MB_10_4	the student knows the experimental methods of rheological survey and main instrumentation	KBF_U07 KBF_W10	4 4
MB_10_5	the student knows the mathematical tensor treatment of rheology	KBF_U02	4

3. Module description

Description	1) The viscosity of liquids: introduction to rheology 2) Flow and deformation: introduction; shear rate and shear stress; dimensions and units 3) The newtonian liquid: viscosity; variation of viscosity with temperature; effects of pressure; limit of newtonian behaviour 4) Some equations for the flow of newtonian liquid: flow in rotational viscometer; flow in straight circular pipes; spheres falling in newtonian liquids; other important flows 5) Viscometry: some important things about using viscometers; viscometer design. 6) Shear—thinning liquid: qualitative features of flow curves; mathematical description of flow curves: models

	7) Equations for the flow of non – newtonian fluids: some selected examples 8) Yield stress fluids: history of the yield stress and yield stress values; flow equations with yield stress 9) The flow of “solids”: non-linear “viscosity” of solids 10) Linear viscoelasticity and time effects: introduction; mechanical analogues of viscoelastic behaviour; measuring linear viscoelasticity : creep and oscillatory tests, response of model materials and real systems; relationship between oscillatory and steady-state viscoelastic parameters; stress relaxation testing and start-up experiments. 11) Non- linear viscoelasticity: everyday elastic liquids; some visible viscoelastic manifestations; proper description of viscoelastic forces and their measurements; some viscoelastic formulas 15) The flow of suspensions: viscosity of dispersions and emulsions; effects of the shape and size of the particles; overview of particle interactions; viscosity of flocculated systems; thixotropy; shear thickening 16) Polymer rheology: different kinds of polymer chains; polymer solutions; polymer melts 17) Rheology of surfactant systems: surfactant phases; rheology of surfactant systems 18) Rheology of food products 19) Extensional flow: the extensional flow; the Trouton ratio; examples of extensional viscosity curves; some applications 20) Recall on scalars, vectors, tensors and their algebra. 21) The stress tensor. Construction, property. 22) Stress ellipsoid. The case of pressure. Deformation tensor. 23) Generalized Hooke's law. Matrix of modules and compliance, its properties. Recalls: differential operators on scalars / vectors / tensors, useful theorems. 24) Conservation of the moment and the mass. Newtonian constitutive equations. Navier Stokes equation. Problems on the flow of incompressible Newtonian fluids: entrainment, f. of poiseuille, f. torsional 25) Material functions and experimental response to steady state flow in simple shear geometry and in extensional geometry. 26) Viscoelasticity and constitutive equations 27) Non-linear viscoelasticity. Cauchy and Finger Tensors. 28) Introduction to more advanced constitutive equations. Models: Integral Lodge, Maxwell Upper / Lower Convected, Cauchy-Maxwell, Rubberlike Liquid Lodge. Quasi-linear models (fluid A and B), non-linear differentials (Oldroyd 8 const.) 29) Other constitutive approaches: molecular approach for polymeric systems. Outline: Configuration distribution function, temporary network model, reptation theory
Prerequisites	

4. Assessment of the learning outcomes of the module

code	type	description	learning outcomes of the module
MB_10_w_1	exam	The modality of verification of the students’ knowledge and skills foresees the continuous interaction with the teacher during the lessons as well as a final oral exam and a presentation of a seminar on a topic previously agreed with the teacher	MB_10_1, MB_10_2, MB_10_3, MB_10_4, MB_10_5

5. Forms of teaching

code	form of teaching			required hours of student's own work		assessment of the learning outcomes of the module
	type	description (including teaching methods)	number of hours	description	number of hours	
MB_10_fs_1	lecture	Detailed discussion by the lecturer of the issues listed in the table "module description"	48	Supplementary reading, working with the textbook	102	MB_10_w_1

		using the table and/or multimedia presentations				