MASTER

Physique fondamentale et applications

SCIENCES SORBONNE UNIVERSITÉ

M1 – Macroscopic and complex systems MU4PYA04

Course: Macroscopic and complex systems	**Code Apogée UE : MU4PYA04**	
	Nombre d'ECTS : 6	
Course coordinators:	Sorbonne Université Name: **Maria BARBI** Address: LPTMC Sorbonne Université case courrier 121 4, Place Jussieu 75252 PARIS cedex 5 Phone: 01 4427 2643 Email: maria.barbi@sorbonne-universite.fr	Université de Paris Name: **Anke LINDNER** Address: PMMH Sorbonne Université Barre Cassan Bat A 1er étage case 18 7 Quai Saint Bernard 75005 PARIS Phone: 01 40 79 58 05 Email: anke.lindner@espci.psl.eu
Number of hours:	**60**	
Semester :	**1**	
Lecture localization:	Campus Jussieu (Sorbonne Université) – Université de Paris	
Laboratories:	no	
Objectives:	This course is designed as an opening towards the study of complex fluids. It is based on two complementary points of view: on the one hand, the microscopic point of view, in which we will approach the bases of inter-molecular interactions and then focus on increasingly complex objects such as polymers, colloids, electrolytes and liquid crystals; on the other hand, the macroscopic point of view of continuous media, which will allow us to describe the larger scale effects of microscopic interactions on the mechanical behavior and the rheology of simple to complex fluids, up to active matter.	
Prerequisites:	• Calculus (integral, differential) • Vector operators • Newtonian mechanics • Basics of electrostatics Useful : • Basics of statistical thermodynamics (statistical entropy, thermodynamic potentials, equipartition theorem, Boltzmann factor)	
Topics/program:	The course "Macroscopic Physics and Complex Systems" will start with an introduction to hydrodynamics and elasticity. The notions of rheology will be given, and some examples of complex fluids discussed, including classical examples as polymer solutions, colloidal suspensions or polyelectrolytes as well as more recent topics as active matter. In all cases the link between microscopic dynamics and macroscopic properties will be established. Phase transitions resulting from molecular interactions will be discussed for liquid crystals and polymer conformations. Capillary phenomena as wetting, capillary rise or super-hydrophobicity will be presented. Nonlinear systems, including instabilities as in oscillatory chemical reactions, will be touched on. Throughout the whole course practical examples from biophysics, soft matter physics, microfluidics and physico-chemistry will be discussed.	
Competences expected after the course:	At the end of this course, students will be able to understand basic concepts, read literature, and solve simple problems related to the following topics : • Basic understanding of simple problems of statistical mechanics related to states of matter, intermolecular forces • Notions of polymer physics • Basic electrostatic interactions in matter, electrolytes, colloidal systems • Basic understanding of simple hydrodynamic problems • Notion of complex versus simple fluids and basic understanding of rheology • Scaling analysis • Basic concepts of linear elasticity and capillarity	
Bibliography:	• « Physical Hydrodynamics », by Guyon, Hulin, Petit, Oxford press • « Fluid-Structure Interactions in Low-Reynolds-Numbers Flows » Edited by Camille Duprat and Howard A. Stone	

	• "Physique de la matière mole" Brochard-Wyart, Nassoy and Puech (in french) Dunod • « Capillarity and Wetting Phenomena » by de Gennes, Brochard-Wyart, and Quere, Springer • « Intermolecular and Surface Forces » by Israelachvili, Elsevier • « Introduction to biopolymr physics » by Van der Maarel, World Scientific • « Giant molecules, Here, there and Everywhere » by Grosberg and Khokhlov, World Scientific • « Basic concepts for simple and complex liquids » by Barrat and Hansen
Evaluation :	**Mid term written examination /20 (CC)** **Article presentation /30 (CC)** **Final written examination /50**
Barèmes (Apogée) :	CC : 50/*100; Écrit : 50*/100