Last update: 11-10-2019

230858 - MSM - Molecular and Soft Condensed Matter

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2019
Degree: MASTER'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2018). (Teaching unit Optional)
ECTS credits: 4 Teaching languages: English

Teaching staff

Coordinator: Roberto Macovez

Others: Roberto Macovez
Carlos Enrique Alemán Llanso

Degree competences to which the subject contributes

Basic:

CB6. (ENG) Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación
CB7. (ENG) Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.
CB9. (ENG) Que los estudiantes sepan comunicar sus conclusiones ¿y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades
CB10. (ENG) Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

Teaching methodology

Theory classes
Excercise classes
Description of some practical applications

Learning objectives of the subject

After taking this course, the students should be able to:
- based on the shape and size of its microscopic constituents, describe the types of condensed phases that can be displayed by a single-component systems, and ascertain which of them are observed at lower or higher temperature;
- describe the main experimental techniques available to identify phases and study molecular dynamics and phase transitions, and explain linear response theory and its main implications;
- discuss the degree of disorder inherent to a condensed phase, and its main characteristic microscopic dynamic processes; discuss the role of disorder and dynamics for rheological and mechanical properties
- use random walk models and percolation and network theory to explain the properties of linear polymers and of polymer networks such as rubbers;
- describe the phenomenology of the glass transition in a number of systems ranging from atomic and molecular structural glasses to plastic crystals, to polymers and colloids;
- enumerate the main technological applications of molecular and soft condensed matter systems, and discuss the relevance of soft condensed matter to explain biological structure formation and biophysical processes.

Study load

Total learning time: 100h	Hours large group:	36h	36.00%
	Self study:	64h	64.00%

Content

(1) BASICS ASPECTS OF ORGANIC CONDENSED MATTER	Learning time: 33h Theory classes: 12h Self study : 21h

Description:

(1a) introduction to condensed phases: microscopic constituents & effective interactions; condensed phases: normal and supercritical fluids, crystals, glasses, mesophases; classification and examples of phase transitions (first order, continuous, glassy); van der Waals theory and isomorphic states; miscibility and binary systems
(1b) disorder & molecular dynamics; linear response theory, dielectric and mechanical spectroscopy; other experimental techniques

Specific objectives:

- based on the shape and size of its microscopic constituents, describe the types of condensed phases that can be displayed by a single-component systems, and ascertain which of them are observed at lower or higher temperature;
- describe the main experimental techniques available to identify phases and study molecular dynamics and phase transitions, and explain linear response theory and its main implications

(2) SINGLE-COMPONENT SYSTEMS	Learning time: 40h Theory classes: 14h Self study : 26h

Description:

(2a) small-molecule condensed phases; crystallization kinetics & polymorphism; structural glasses, ultrastable & aged glasses; orientationally disordered solids & plastic crystals; primary & secondary relaxations; charge transport properties
(2b) bulk homopolymers; amorphous & semicrystalline linear polymers; ideal chain statistics and entanglement effects, entropic spring constant, Rouse modes & reptation; polymer glass transition & crystallization; viscoelasticity; branched polymers & networks, gelation and rubber elasticity, affine network model; conjugated and conductive polymers
(2c) thermotropic liquid crystals (nematic, smectic, columnar) and liquid crystal polymers; optical properties & applications

Specific objectives:

- discuss the degree of disorder inherent to a condensed phase, and its main characteristic microscopic dynamic processes; discuss the role of disorder and dynamics for rheological and mechanical properties
- use random walk models and percolation and network theory to explain the properties of linear polymers and of polymer networks such as rubbers

(3) BINARY AND AQUEOUS SYSTEMS	Learning time: 27h Theory classes: 10h Self study : 17h

Description:

(3a) Polymer solutions, non-ideal chains, theta-solutions, hydrogels; swelling phenomena; superhydrophobic/hydrophilic, superolephobic, superamphiphilic, and self-healing polymer coatings; biopolymers, helix-coil & coil-globule transitions
(3b) Self-assembly in condensed matter: specific & non-specific interactions; block copolymers; colloidal systems (glasses, crystals, gels), surfactant-water systems, biomembranes, lyotropic liquid crystals, emulsions; semiflexible polymers & cytoskeleton.

Specific objectives:

- describe the phenomenology of the glass transition in a number of systems ranging from atomic and molecular structural glasses to plastic crystals, to polymers and colloids;
- enumerate the main technological applications of molecular and soft condensed matter systems, and discuss the relevance of soft condensed matter to explain biological structure formation and biophysical processes.

Qualification system

The students' grading system will consist of an evaluation during the course, based on three elements: a series of homework problems to be solved by the student on his/her own and handed in (TE), a report on a research topic linked with the course and based on recent scientific publications, and the presentation of the content of the report in front of the class (EP).
The final mark will be given by:
{0.4*TE + 0.3*RI + 0.3*EP}

Bibliography

Basic:

Jones, R.A.L. Soft condensed matter. Osford: Oxford University Press, 2002. ISBN 0198505892 (PBK.).

Papon, P.; Leblond, J.; Meijer, P.H.E.. The physics of phase transitions, concepts and applications. 2nd ed. Berlin: Springer, 2006. ISBN 3540333894.

Rubinstein, M.; Colby, R.H. Polymer physics. Oxford: Oxford University Press, 2003. ISBN 9780198520597.

Complementary:

Strobl, G.. Condensed matter physics: crystals, liquids, liquid crystals, and polymers. Berlin: Springer, 2003. ISBN 3540003533.

Mattsson, J. "The glass transition". Fluids, colloids and soft materials: an introduction to soft matter physics [on line]. Hoboken, New Jersey: John Wiley & Sons, 2016. 13, pp.249-278 [Consultation: 03/10/2018]. Available on: <https://onlinelibrary.wiley.com/doi/book/10.1002/9781119220510>.

"Dispersion and oscillating fields in dispersive media". Reitz, J.R.; Milford, F.J.; Christy, R.W. Foundations of electromagnetic theory. Reading, Mass: Addison Wesley, 2008. 19.