# Course guide
# 295554 - 295EQ022 - Polymer Physics

**Last modified:** 04/06/2026

**Unit in charge:** Barcelona East School of Engineering
**Teaching unit:** 713 - EQ - Department of Chemical Engineering.

**Degree:** MASTER'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2019). (Compulsory subject).
ERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2021). (Optional subject).
MASTER'S DEGREE IN POLYMERS AND BIOPLASTICS (Syllabus 2024). (Compulsory subject).

**Academic year:** 2026 **ECTS Credits:** 6.0 **Languages:** English

## LECTURER

**Coordinating lecturer:** MARIA DEL MAR PÉREZ MADRIGAL

**Others:** Primer quadrimestre:
JORDI SANS MILÀ - Grup: T1
JUAN TORRAS COSTA - Grup: T1

## PRIOR SKILLS

Basic knowledge in Organic Chemistry and Polymers.

## DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

**Specific:**
CEMUEQ-01. To apply knowledge of mathematics, physics, chemistry, biology and other natural sciences, obtained through study, experience and practice, with critical reasoning, to establish economically viable solutions to technical problems
CEMUEQ-04. Ability to solve problems that are unfamiliar, ill-defined, and have opposed specifications, considering the possible solution methods, including the most innovative, selecting the most appropriate, and being able to correct the implementation, evaluating the different design solutions

**Generical:**
CGMUEQ-01. Ability to apply the scientific method and the principles of engineering and economics, to formulate and solve complex problems in processes, equipment, facilities and services, in which the matter undergoes changes in its composition, state or energy content, characteristic of the chemical industry and other related sectors among which are the pharmaceutical, biotechnological, materials, energy, food or environmental

**Transversal:**
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

## TEACHING METHODOLOGY

MD.1. Learning contract; MD.2. Master lesson; MD.5. Learning based on projects, problems and cases.

## LEARNING OBJECTIVES OF THE SUBJECT

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## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Hours large group | 54,0 | 36.00 |
| Self study | 96,0 | 64.00 |

**Total learning time:** 150 h

## CONTENTS

### Basic characterization

**Description:**
Spectroscopic methods. Applications of UV, FTIR and NMR techniques. Stereochemistry of polymers and study of sequences. Chromatographic applications. Molecular weights averages. Polymer dissolution. Solubility parameters. Group contribution theory.

**Specific objectives:**
To get an acknowledgement on the physical principles related to the techniques used in the basic characterization of polymers. To get the ability to perform a basic interpretation of spectra. To know the bases of the gel permeation and its application for the determination of average molecular weights. To get the ability to select the best solvent for a particular polymer and become familiar with the theory of group contributions for the prediction of properties.

**Related activities:**
Resolution of exercises concerning the analysis of spectra and chromatograms.

**Full-or-part-time:** 14h
Theory classes: 6h
Self study : 8h

### Physical Chemistry of Polymers

**Description:**
Thermodynamics of concentrated solutions. Phase separation. Flory temperature. Polymer fractionation. Polymer blends. Phase diagram. Random coils. Molecular interactions and excluded volume. Thermodynamics of diluted solutions. Measurements of molecular weights: Colligative properties,viscosity, light scattering.

**Specific objectives:**
To get an acknowledgement on the theoretical principles that govern the behavior of polymers in both diluted and concentrated solutions. To relate the theoretical concepts with their practical application in separation and fractionation processes as well in the characterization of mixtures or blends, or in the basic characterization of polymeric materials.

**Related activities:**
Resolution of a collection of practical problems and exercises of a theoretical nature that allow to improve the understanding of theroretical concepts introduced in this section.

**Full-or-part-time:** 36h
Theory classes: 12h
Self study : 24h

**The solid state. Methods of structural characterization.**

**Description:**
The amorphous state: short and long-range interactions. Macromolecular dynamics. The crystalline state: Molecular requirements and levels of supramolecular organization. Conformation and molecular packaging.
Crystalline morphologies: Delgas, spherulites and fibers. Structural characterization methods: X-ray diffraction and electron microscopy. Atomic force microscopy.

**Specific objectives:**
To acquire basic notions about the inter and intramolecular interactions that determines the molecular organization of both amorphous and crystalline states. To understand the crystallization process and justify the morphologies that derive from it. To become familiar with the main techniques used in the structural analysis and be able to select that most suitable to solve a specific problem.

**Related activities:**
Resolution of exercises aimed to facilitate the understanding of the molecular organization in the crystalline state and the deduction of the most characteristic structural parameters.

**Full-or-part-time:** 36h
Theory classes: 12h
Self study : 24h

**Thermal properties of polymers. Analysis techniques.**

**Description:**
Transitions of first and second order. Dilatometry. Differential scanning calorimetry. Melting temperature, molecular structure and composition. Crystallization of polymers. The glass transition. Thermogravimetric analysis.

**Specific objectives:**
To relate the chemical and crystallographic structure of a polymer with the thermal properties of both amorphous and crystalline states. Become familiar with the main techniques used in the calorimetric analysis of a polymer.

**Related activities:**
Interpretation of representative calorimetric scans of different classes of polymers. Exercises concerning crystallization kinetics.

**Full-or-part-time:** 22h
Theory classes: 8h
Self study : 14h

**Mechanical properties of polymers. Analysis techniques.**

**Description:**
Mechanical tests Mechanical and rheological properties. Tension-deformation behavior of elastomers. Models of viscoelastic behavior. Time-temperature equivalence Dynamomechanical techniques. Relaxation mechanisms.

**Specific objectives:**
To get an understanding of the different mechanical behaviors of materials and how they can be related to the chemical structure and temperature. To understand the effect of time and relaxation mechanisms. To acquire knowledgement about the different mechanical tests.

**Related activities:**
Resolution of representative exercises paying special attention to the viscoelastic behavior and the rheological properties in general.

**Full-or-part-time:** 22h
Theory classes: 8h
Self study : 14h

**Specific properties. Multicomponent systems.**

**Description:**
Electrical and optical properties of polymers. Adhesive materials. Diffusion and permeability: Membranes. Multicomponent composite materials: Young's module. Mechanisms of mechanical properties loss.

**Specific objectives:**
To get a generic knowledge about the specific properties of polymers that justify their use as optical materials, conductors or membranes. To introduce the study of multicomponent materials and explain their interest for the improvement of specific properties.

**Related activities:**
Individual work on the properties of a specific material, correlating them with the knowledge acquired about its structure.

**Full-or-part-time:** 20h
Theory classes: 8h
Self study : 12h

## GRADING SYSTEM

Any academic fraud, plagiarism or use or possession of unauthorised means in an assessment activity leads to a mark of zero (0) for the affected test or assignment. Furthermore, in accordance with the University's regulations, if disciplinary proceedings are initiated the subject is recorded as "Pending Assessment" until a decision is reached. These incidents are managed in accordance with the **Action Framework for Academic Integrity in Assessment at the UPC**.

IE.1. Written exam, IE.3. Questions, tests, problems, mini reports.

## EXAMINATION RULES.

Two exams will be carried out during the course, each representing 25% of the overall score (the second exam will be performed at the date of the final examination test); the presentation of reports and proposed problems will correspond to 30% and the monographic work 20%. No reevaluation test will be carried out.

## BIBLIOGRAPHY

**Basic:**
- Sperling, Leslie Howard. Introduction to physical polymer science. 4th ed. Hoboken, N.J.: Wiley, cop. 2006. ISBN 9780471706069.
- Painter, Paul C; Coleman, Michael M. Essentials of polymer science and engineering. Lancaster: DEStech Publications, cop. 2009. ISBN 9781932078756.

**Complementary:**
- Strobl, Gert. The Physics of polymers : concepts for understanding their structures and behavior [on line]. 3rd. Berlin ; London: Springer Verlag, cop. 2007 [Consultation: 13/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=3062750. ISBN 9783540252788.
- Fried, Joel R. Polymer science and technology. 3rd ed. Upper Saddle River: Prentice Hall, cop. 2014. ISBN 9780137039555.
- Reiter, G; Strobl, Gert (eds.). Progress in understanding of polymer crystallization [on line]. Berlin ; London: Springer, cop. 2007 [Consultation: 13/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=3036604. ISBN 9783540473053.
- Wunderlich, Bernhard. Thermal analysis of polymeric materials : with 974 figures. New York: Springer Heidelberg, cop. 2005. ISBN 3540236295.
- Ward, Ian Macmillan; Sweeney, J. An introduction to the mechanical properties of solid polymers. 2nd ed. Chichester: John Wiley & Sons, cop. 2004. ISBN 047149626X.