Course guide
295757 - 295EM112 - Structure and Properties of Polymers

Last modified: 04/06/2026

Unit in charge: Barcelona East School of Engineering
Teaching unit: 702 - CEM - Department of Materials Science and Engineering.

Degree: ERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Optional subject).
MASTER'S DEGREE IN MATERIALS SCIENCE AND ADVANCED MATERIALS ENGINEERING (Syllabus 2019). (Optional subject).
ERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2021). (Compulsory subject).

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

LECTURER

Coordinating lecturer: ORLANDO ONOFRE SANTANA PEREZ

Others: Primer quadrimestre:
NICOLAS CANDAU - Grup: T1
LEANDRO ISIDRO MARTÍNEZ OROZCO - Grup: T1
ROSE MARY RITA MICHELL URIBE - Grup: T1
ORLANDO ONOFRE SANTANA PEREZ - Grup: T1

PRIOR SKILLS

Knowledge of materials structure, organic chemistry, physics, mathematics.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMCEAM-01. (ENG) Dissenyar i desenvolupar productes, processos i sistemes, això com l'optimització d'altres ja desenvolupats, atenent a la selecció de materials per aplicacions específiques.

Transversal:
02 SCS. SUSTAINABILITY AND SOCIAL COMMITMENT. Being aware of and understanding the complexity of social and economic phenomena that characterize the welfare society. Having the ability to relate welfare to globalization and sustainability. Being able to make a balanced use of techniques, technology, the economy and sustainability.
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

TEACHING METHODOLOGY

During the course there will be three types of sessions: theory, problems, and laboratory practices. In addition autonomous learning to relate knowledge acquired in practices with theoretical fundaments. Two exams will take place.

LEARNING OBJECTIVES OF THE SUBJECT

Acquire knowledge about structure, obtaining, physical and mechanical properties of polymeric materials.

STUDY LOAD

Type	Hours	Percentage
Hours large group	28,0	18.67
Hours small group	14,0	9.33
Self study	108,0	72.00

Total learning time: 150 h

CONTENTS

Topic 1: Introduction, structure and clarification

Description:
Brief history of polymer science and technology.
Technological importance of polymeric materials.
Idealization of the polymer chain, preliminary definitions.
Configuration and conformation of the chains: isomerisms, molecular architecture, chain mobility.
Classification based on thermomechanical behavior: thermoplastics, thermosets and elastomers.
Classification based on consumption: "Comodities", Engineering and special applications.

Related activities:
Suggested reading and discussion-debate in class.

Full-or-part-time: 5h 42m
Theory classes: 3h
Self study : 2h 42m

Topic 2: Synthesis: Polymerization and copolymerization

Description:
Preliminary definitions: Monomers, Coppers, monomer functionality, Repetitive unit vs. Structural unit, Homopolymers vs. Copolymers
Main polymerization mechanisms:
- In chain: radicalar, anionic and cationic.
- By steps: Polycondensation vs. Polyaddition
Main polymerization processes:
- Mass
- In solution
- In suspension
- In emulsion

Full-or-part-time: 8h 24m
Theory classes: 3h
Self study : 5h 24m

Topic 3: Dimensions of the chains

Description:
Solubility in polymers: good, poor solvent. Condition "teta" of a solvent.
Characteristic ratio and radius of rotation.
Distribution of molecular masses and average molecular masses: By weight, in number, viscosimetric, and third moment of distribution. Technological importance of its determination.
Molecular mass determination techniques:
- Viscosimetry
- Chromatography by size exclusion
- Light scattering
- Osmometry

Related activities:
Lab. 1.

Full-or-part-time: 12h 36m
Theory classes: 3h
Laboratory classes: 1h 30m
Self study : 8h 06m

Topic 4: Thermal transitions and aggregation states.

Description:
Glass transition (Tg).
Melting temperature (Tm).
States of aggregation as a function of temperature.
Techniques for determining transition temperatures:
- Differential scanning calorimetry (DSC.
- Thermomechanical analysis (TMA).
- Softening temperatures: HDT and VICAT

Full-or-part-time: 4h 42m
Theory classes: 1h 30m
Self study : 3h 12m

Topic 5: Organization in the Solid State

Description:
Disorder:
- Amorphous polymer as sub-cooled liquid.
- Structural factors that affect the vitreous transition.
- Vitrification as a kinetic process.
- Volumetric relaxation vs. Entálpica relaxation: Physical aging.

Order:
- Crystal structures: Lamela, spherulite, Sheas Kebab, Row nucleated
- Isothermal and non-isothermal crystallization process.
- Factors that affect crystallization ability.
- Melting process in polymers.

Related activities:
Lab. 2.
Lab. 3.

Full-or-part-time: 29h 24m
Theory classes: 7h 30m
Laboratory classes: 3h
Self study : 18h 54m

Subject 6. Strcture-mechanical properties relationship.

Description:
Plane stress state and plane strain state: triaxiality.
Stress-Strain curves in polymers: Engineering, true and intrinsic.
Practical aspects of the determination of stress-strain curves in polymers. Consider construction.
Phenomenology of the deformation process in polymers: Energy elasticity, entropic elasticity (elasticity of rubber), plastic deformation, hardening by deformation (natural draw ratio).
Relationship between structure and intrinsic stress-strain curves in polymers: efect of Molecular Weight, aggregation state, orientation, cristalline texture.
Mechanism of plastic deformation in polymers: Shear yielding vs. Crazing
Enviromental Stress Cracking (ESC).
Ductile-brittle transition in polymers.

Related activities:
Lab. 4

Full-or-part-time: 21h
Theory classes: 6h
Laboratory classes: 1h 30m
Self study : 13h 30m

Subject 7. Polymer viscoelasticity

Description:
Viscoelasticity as a consequence of the macromolecular nature.
The concept of time characteristic of the process.
Effect of the viscoelastic nature on quasi-static mechanical tests.
Linear viscoelasticity: Principle of stress / strain superposition (Boltzmann) and time-temperature correspondence. Generation of master curves.
Responses in static loadings: Creep, Relaxation of tensions, Creep-recovery (quantification parameters). Micromechanical models used (Maxwell, Kelvin voight, 3 elements, Bruger). Isochrone and isobaric curves.
Responses to cyclic loading: Storage modules, loss, dissipation factor. Micromodelos employees.
DMTA assays in polymers.

Full-or-part-time: 30h 24m
Theory classes: 7h 30m
Laboratory classes: 3h
Self study : 19h 54m

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**.

3 partial exams (NPP-1; NPP-2 and NPP-3) + Continuous evaluation (NEC).

All evaluations will be on a scale of 10. IMPORTANT: ALL EVALUATION ITEMS ARE MANDATORY IN ORDER TO PASS THE SUBJECT.

The final grade (NF) will be calculated from the following expression:

NF = 0.7NTory + 0.3 NEC (Continuous Assessment)

NEC: average of group activities (homework/lab reports, a total of 5).

NTheory = average of the 3 partial tests

In case of NTheory < 5, a final exam must be presented. In this case, the "new" Ntheory to be considered for the calculation of the Final Grade (NF, according to the initial equation) of the subject:
NTheory= 0.3*(Average Partial Tests) + 0.7*EF

EXAMINATION RULES.

The partial exams (ExPr) will be done within the schedule of the subject. No notes, unless instructed to do so by the teacher. They will have a maximum duration of 75 min.
Laboratory reports will be presented in groups of up to 3 students one week after the session. A template for writing will be available

BIBLIOGRAPHY

Basic:
- Ehrenstein, Gottfried W. Polymeric materials : structure, properties, applications. Hanser Publisher, 2001. ISBN 9781569903100.
- Young, Robert J.; Lovell, Peter A. Introduction to polymers [on line]. 3rd ed. Boca Raton [etc.]: CRC Press, cop. 2011 [Consultation: 13/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1460729. ISBN 9781439894156.
- McCrum, N. G.; Buckley, C. P.; Bucknall, C. B. Principle of polymer engineering. 2nd ed. Oxford [etc.]: Oxford University Press, 1997. ISBN 0198565267.

Complementary:
- Gilbert, Marianne. Brydson's plastics materials. 8th ed. Butterworth-Heinemann, 2016. ISBN 9780323358248.
- Ward, I. M.; Sweeney, J. An Introduction to the mechanical properties of solid polymers. 2nd ed. Wiley, 2005. ISBN 047149626X.
- Physical properties of polymers handbook. 2nd ed. New York: Springer-Verlag, cop. 2007. ISBN 9780387312354.

RESOURCES

Other resources:
In the digital campus of the subject will be placed, prior to the theoretical sessions, the visual support material used in the class sessions, as well as the scripts of laboratory practices and the technical report template to be used in the presentation of the laboratory reports.