

# Structural performance of polymers and their composites

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**Subject area:** Mechanical Engineering

**University:** TU/e  
**Level:** MA all years  
**Teaching mode:** hybrid: some students participate online, other students attend real-life  
**Instructor(s):** Dr. ir. T.A.P. Engels and Dr. ir. L.E. Govaert

## Short description

Designing for the structural performance of applications based on polymers and polymer based composites requires understanding of how these materials behave under relevant loading conditions. In this course we address the basics of polymer processing and mechanics, composite theory and long-term performance, required to understand their performance and how it can affect the final application.

## Full description

"Modern engineering practice places ever-increasing demands (eg. load, temperature, time) on the structural performance of polymers. Whereas new polymers are still being developed to meet these increasing demands, another important route for meeting them is by increasing our understanding of these systems and translating that understanding into tools that allow for smaller safety margins to be used in the application. Essential for polymers in that respect is a high level of understanding of how processing and final properties are connected since it is not only the chemical composition of the system that determines its final properties and eventual failure, but to a large extent also the processing history experienced while being converted into an actual product.

The various failure phenomena that may occur in polymers and their composites in short-term (impact) or long-term (static or cyclic fatigue) loading will be discussed in detail. We will focus on mechanically induced failure, and will distinguish between ductile failure modes, i.e. controlled by plasticity, and brittle failure modes, governed by crack growth; the domain of fracture mechanics. The fundamentals of both failure regimes will be covered and the main methods to predict their response will be introduced and demonstrated.

The lecture series will start with a general introduction to, and reflection on, polymers and plastics. Next, essentials with respect to polymer flow and processing will be briefly discussed, as they will be of influence the mechanical performance of the polymer in the final application. The main bulk of the lecture series will then focus on short-term properties of polymers and polymer composites, their long-term performance under fatigue loads where either plasticity governed failure dominates at shorter times and higher loads, or crack-growth dominated failure at lower loads at longer failure times. The

course will end with a series of guest lectures given by industry experts that reflect on polymer mechanical performance within the context of their specific area and/or market of focus."

## Learning outcomes

"After passing the course the student is able to

- Understand and remember the concepts of failure in polymers and polymer composites: slow crack growth, ductile flow and fracture;
- Understand and remember the molecular concepts that influence and govern these three failure modes;
- Analyze and apply the concepts of phenomenological modeling that allows you to describe and predict failure caused by these three failure modes;
- Understand and remember the concepts that govern the enhancement of mechanical properties in polymer-based composites;
- Analyze and apply the concept of composite modeling to describe and predict the mechanical performance of polymer-based composites;
- Understand and remember the concepts that describe how processing conditions influence the mechanical properties of polymers and polymer composites;
- Analyze observed mechanical behavior of polymers and polymer-based composites and by reflection be able to make proposals for improvement."

## General information

<b>Contact hours per week:</b>	6
<b>Total workload:</b>	140 (in student hours for the whole course)
<b>ECTS credits:</b>	5
<b>Language:</b>	English
<b>Course start date:</b>	05 September 2022
<b>Course end date:</b>	12 November 2022
<b>Add. info about start date:</b>	
<b>Weekly teaching day/time:</b>	Tuesday mornings and Friday afternoons
<b>Time zone:</b>	CET (Denmark, Germany, France, Netherlands, Switzerland, Czech Republic)
<b>Further information:</b>	Hybrid: lectures will be given in person at the Eindhoven University of Technology and can be attended via Teams. Interaction via Teams is possible and is encouraged. The lectures will also be recorded, allowing the student to watch them (again) at a later time.

**Prerequisites:**

"The course can be successfully completed without any specific prior knowledge, as long as the participant has a bachelor's degree in engineering. Knowledge of (polymer) mechanics, rheology and composite theory is advantageous. Students that lack this knowledge will be provided with references that allow them to acquire it.

There are a number of generic textbooks that can help you get up to speed, e.g. Polymers, from structure to properties by

Leon Govaert, Martin van Drongelen and A.K. van der Vegt (ISBN/EAN 9789065624444 )."

**Activities and methods:** Lectures, Group work, Tutorial sessions

**Presence on campus:**

## Final examination

**Form:** written  
**Date:** 31 October 2022  
**Location/format:** online  
**Re-sit possibility:** yes  
**Transcript available:** end of semester  
**Add. info/requirements:** standard calculator

## Registration

To register for this course, follow the registration requirements of your **home university** as specified here: [www.euroteq.eu/courses-registration](http://www.euroteq.eu/courses-registration).

## Administration

**Number of places:**  
**Minimum participants:**  
**Internal course code:** 4LM60  
**Contact:** T.A.P.Engels@tue.nl

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