הטכניון מכון טכנולוגי לישראל TECHNION Israel Institute of Technology

Faculty of Mechanical Engineering הפקולטה להנדסת מכונות

# MECHANICAL ENGINEERING MSc SEMINAR (30 min.)

**Thursday, September 11, 2025 at 13:30-14:00**, D. Dan and Betty Kahn Building, Room 217

## Non-Newtonian fluid flows through contraction-expansion channels


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Pressure-driven flows of non-Newtonian fluids in narrow and confined geometries are widely encountered in natural processes and technological applications. Example include physiological flows such as blood transport through micro-vessels (e.g., arterioles and venules), industrial applications involving polymeric materials, and small-scale fluidic devices like micro-viscometers, viscoelastic rectifiers, and subcutaneous drug delivery systems. Complex fluid flows may exhibit significantly different behavior from Newtonian flows due to intricate rheological characteristics, such as shear thinning and viscoelasticity. These rheological characteristics influence the hydrodynamic features of non-Newtonian flows, including the relationship between the pressure drop $\Delta p$ and the flow rate $q$, which remains poorly understood to date even at low Reynolds numbers.

In the first part of my talk, I will present a theoretical framework for calculating the flow rate-pressure drop relation of shear-thinning fluids in contraction-expansion (constriction) channels. Using the Carreau model that reproduces the realistic rheological behavior of shear-thinning fluids over the whole range of shear rates, we are able to derive closed-form expressions and asymptotic solutions for the pressure drop of a Carreau fluid across different flow regimes. I will discuss how shear-thinning behavior influences the pressure drop behavior and show that our analytical predictions are in excellent agreement with finite-element numerical simulations.

In the second part of my talk, I will discuss the flow of viscoelastic dilute polymer solutions in narrow channels. Describing the fluid viscoelasticity using the Oldroyd-B equation, which is the simplest continuum model for viscoelastic fluids derivable from microscopic principles, I will present a theoretical framework for calculating the elastic stresses and flow rate-pressure drop relation in slowly varying constriction channels. I will demonstrate that our theoretical predictions based on the Oldroyd-B model, which are valid for arbitrary values of the Deborah number, show excellent agreement with finite-element numerical simulations. Finally, I will discuss the physical mechanisms that govern pressure drop behavior of viscoelastic fluids in constriction channels, and compare and contrast them with predictions of the well-studied contraction geometry.

Note: the seminar will be given in English

Seminars Coordinator: Assoc. Prof. Shmuel Gal.