



## MECHANICAL ENGINEERING SEMINAR

Monday, April 27, 2026 at 14:30, Lady Davis Building, Auditorium 250\*

\*pending Home Front Command guidelines for that period

Online: <https://technion.zoom.us/j/92555577895>

### Learning in complex physical systems: From quasistatics to dynamics

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**Hosted by: Prof. Alon Wolf**

Complex systems, ranging from disordered materials and artificial neural networks to living matter, are characterized by many strongly interacting degrees of freedom that give rise to rich collective behavior. It is well appreciated that tuning their numerous microscopic parameters enables the design of nontrivial functionalities, including tailored elastic responses, collective motion, self-assembly, and data classification. Traditionally, such functionality has been achieved through computational optimization. More recently, however, the fusion of ideas in learning theory and mechanics of disordered systems has opened a new possibility: physical systems, such as, mechanical structures, flow and resistor networks, that autonomously learn their function directly.

In this paradigm, learning is governed by local rules, where the evolution of microscopic parameters depends only on locally accessible information, such as strain, stress, or flow rate. This approach provides a route for mechanical structures that can learn, efficient neuromorphic computation, and understanding learning-like behavior in biological systems that lack neurons.

In this talk, I will present our efforts to formulate such local learning rules in elastic, viscous, and electronic systems. Our central goal is to extend physical learning ideas from the quasistatic limit to fully dynamical settings governed by damped Newtonian dynamics. Our approach builds on defining variational functionals, analogous to an action, whose extrema determine the system's trajectories across different dynamical regimes. As a proof of concept, I will show how this framework enables control of the rate-dependent response of viscoelastic structures and how it can be used to design elastic structures and electronic circuits that can be trained to classify temporal signals, such as spoken words.

More broadly, this work establishes a scalable route for controlling the dynamics of complex systems, enabling functionalities that intrinsically depend on time and history, frequency-selective filtering, classification of temporal signals, and rate-dependent responses.