# MECHANICAL ENGINEERING STUDENT SEMINAR

**Wednesday, June 19th, 2024, at 13:30**, D. Dan and Betty Kahn Building, Room 217.
**Online: ZOOM LINK**

## Nonholonomic dynamics of the dissipative Twistcar vehicle - towards an actuated system with passivity


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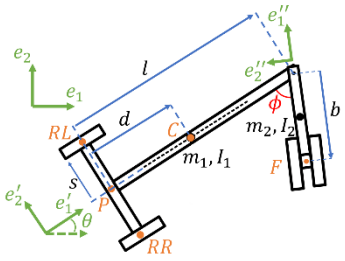
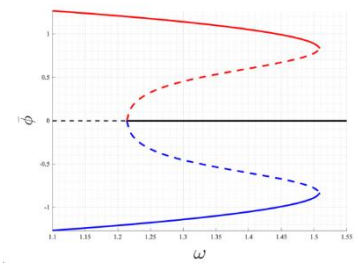
Underactuated wheeled vehicles are commonly studied as nonholonomic systems with periodic actuation. **Twistcar** is a classic example inspired by a riding toy, which has been analyzed using a planar model of a dynamical system with nonholonomic constraints. Prior analytical investigations of this model, under the assumption of zero dissipation, have revealed nonlinear phenomena, including direction reversals depending on the geometric and mass properties of the vehicle. Motivated by the dissipative and bounded motion observed in experiments with Twistcar robotic prototypes, in this work, we extend the analysis of the model to a dissipative system. Adding **rolling dissipation** to the no-skid Twistcar model leads to bounded oscillations in the vehicle's speed and body orientation angle, which better agrees with experimental observations. Reduced-order formulation enables straightforward numerical exploration for stable periodic solutions, depending on parameter changes in the system. Further asymptotic analysis predicted well the occurrence of reversals and choice of parameter to optimize body velocity. Next, motivated by non-negligible wheel skidding indicated in experimental work, we consider a modified model which accounts for **wheel skidding under viscous friction**. Numerical analysis uncovers a spectrum of phenomena, including direction reversals and optimization in locomotion performance with respect to parameters. Finally, another variant model we consider is the Passive Steer-free Rotor-Actuated Vehicle (PSI-RAV), inspired by skateboards such as Waveboard. This model has richer locomotion behaviors while possessing a **passive joint** within the model, under simple periodic actuation. Varying parameters such as actuation frequency and structural length ratio lead to **bifurcations, stability transitions**, and symmetry breaking of periodic solutions.


Note: the seminar will be given in English

Seminars Coordinator: Assoc. Prof. Gal Shmuel.