

# Control Systems Lab Series

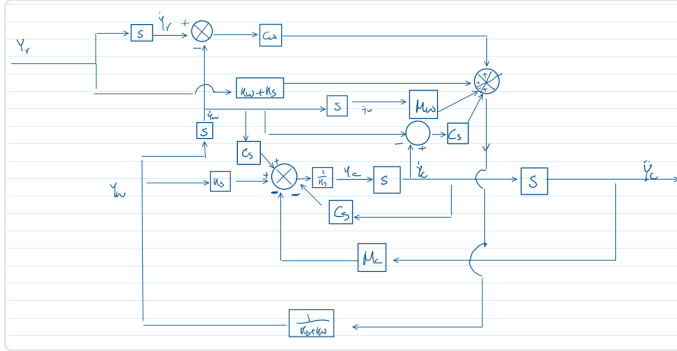
University of Toronto, MIE404 (Control Systems I) · Fall 2024 · Group of three

Modeling and control

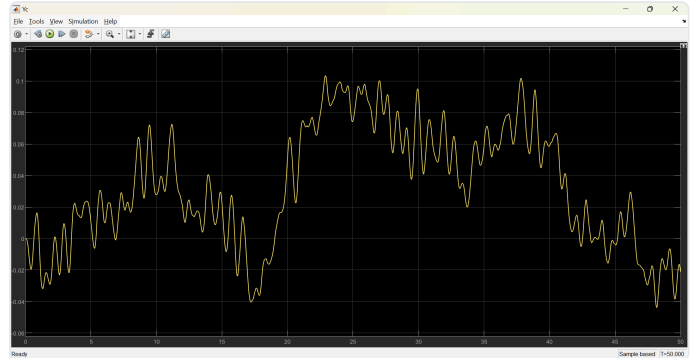
Simulation

## Four feedback-control labs, from equations of motion to stabilizing a real unstable plant.

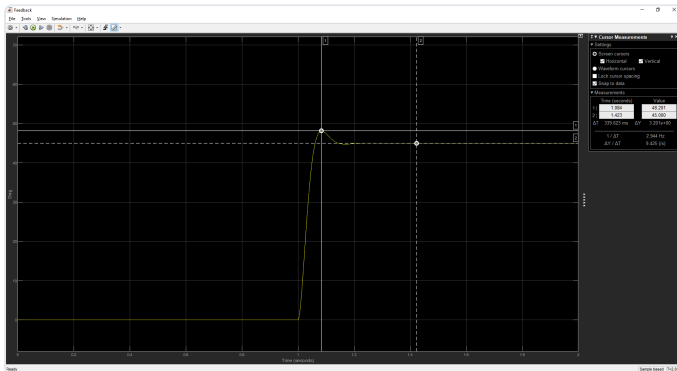
A four-lab sequence in classical control. Each lab takes a system from its equations of motion through transfer-function design to a tuned, validated controller, across a quarter-car suspension, power-grid voltage regulation, airfoil position control, and a magnetic-levitation plant. The work spans hand derivation, MATLAB analysis, and Simulink.



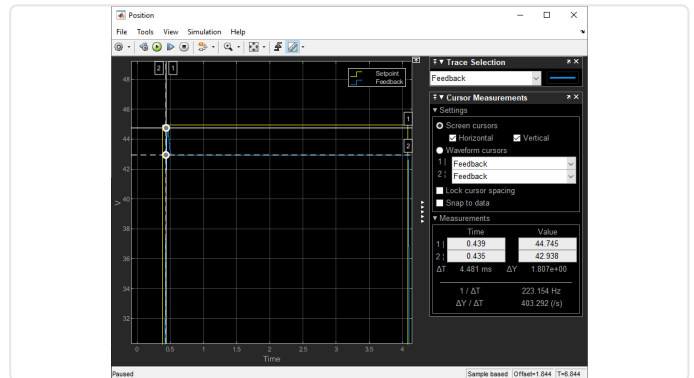
Hand-derived quarter-car suspension control block diagram.



Simulated chassis displacement response of the suspension model.



Closed-loop PID block diagram for airfoil position control.



Tuned step response, calculated against simulated within about 1%.

## Modeling and design

Each lab derives a plant transfer function in the Laplace domain, then designs a controller for it, including a PI controller for grid voltage with deliberate zero placement and a PID position controller for an airfoil tuned to a target rise time and overshoot.

## Validation

Designs were checked against simulation in Simulink and MATLAB Control System Designer. The airfoil PID matched its analytical rise-time and overshoot predictions within about 1%, and the suspension model showed high-frequency road content removed from the car-body motion.

## SELECTED REFERENCES

- Aircraft Pitch: PID Controller Design, University of Michigan CTMS.
- "Enhancement of Ride Comfort in Active Quarter-Car Suspension using MPC," Int. J. of Automotive Science and Technology, 2024.
- "Stabilization of the Magnetic Levitation System," Applied Sciences (MDPI) 11(21), Nov 2021.

Engineering portfolio brief. Course and team project; contribution as noted above.