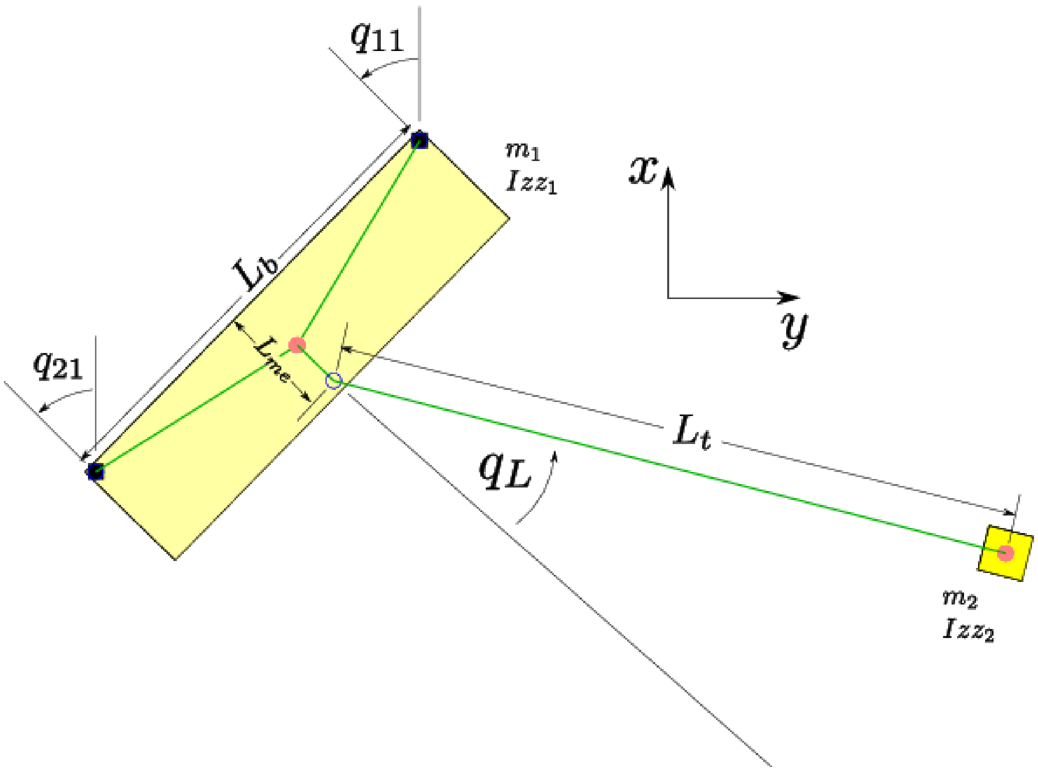
ROCR Model



m_1	$0.335\ kg$
Izz_1	$0.0032\ kg\text{-}m^2$
m_2	$0.3\ kg$
Izz_2	$0.0\ kg\text{-}m^2$
L_b	$0.305\ m$
L_{me}	$0.07\ m$
L_t	$0.457\ m$

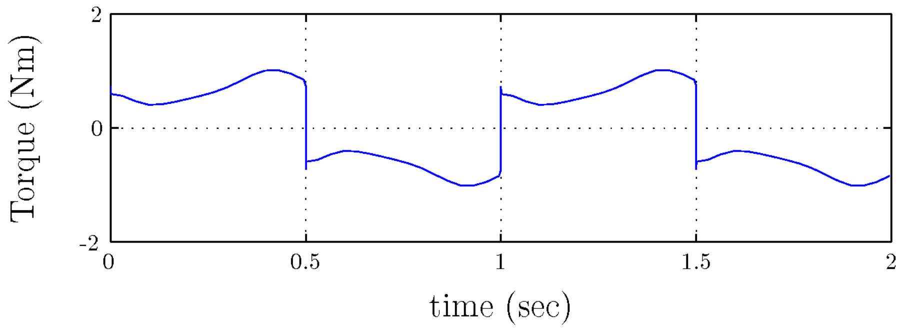
Desired path to improving ROCR climbing

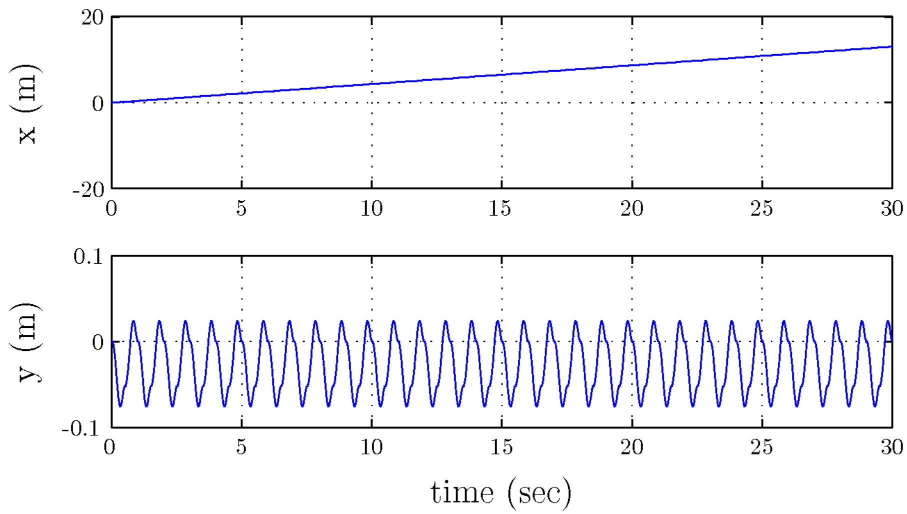
1. Use optimization routines to find minimum time steady-state trajectory for a given initial condition.

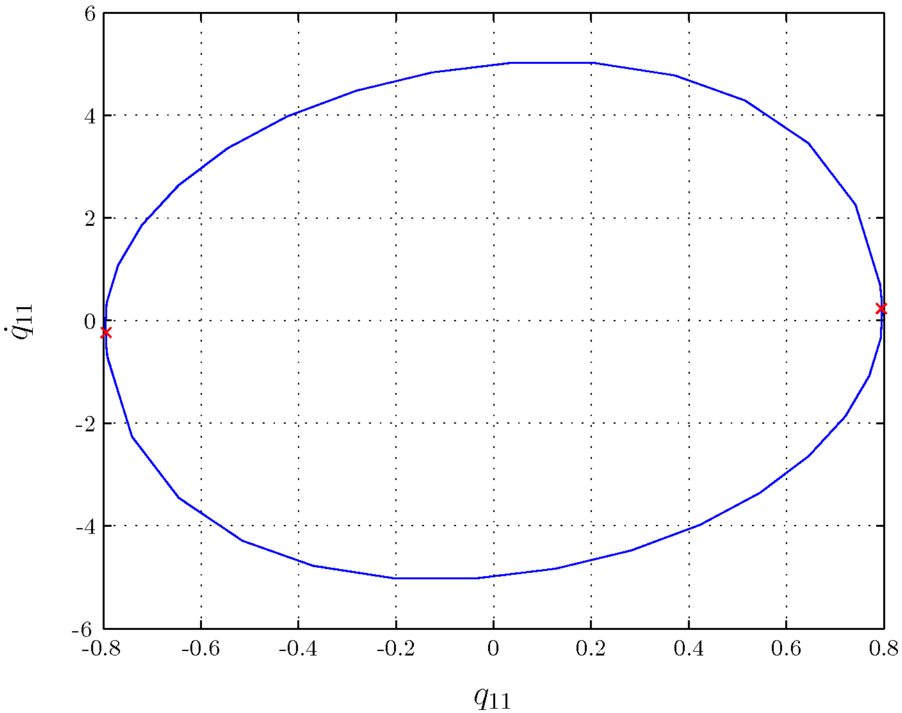
2. Investigate performance over a range of initial conditions.
   - Power required, robustness, reaction forces required, etc.

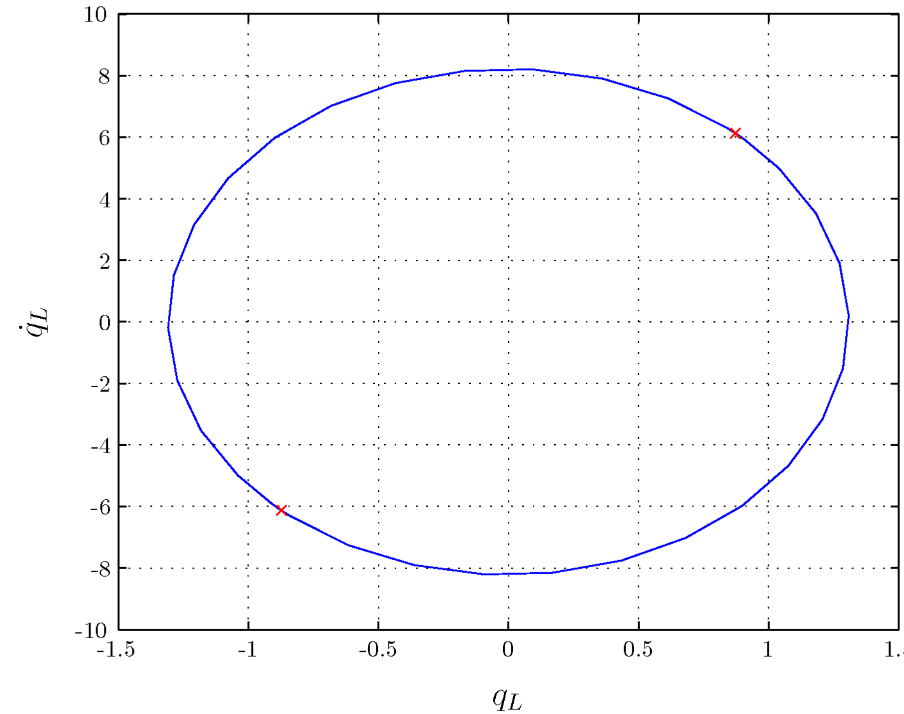
3. Repeat optimizations with added contact constraints and/or actuator limitations.

Trajectory-based control – High contact damping (30%)





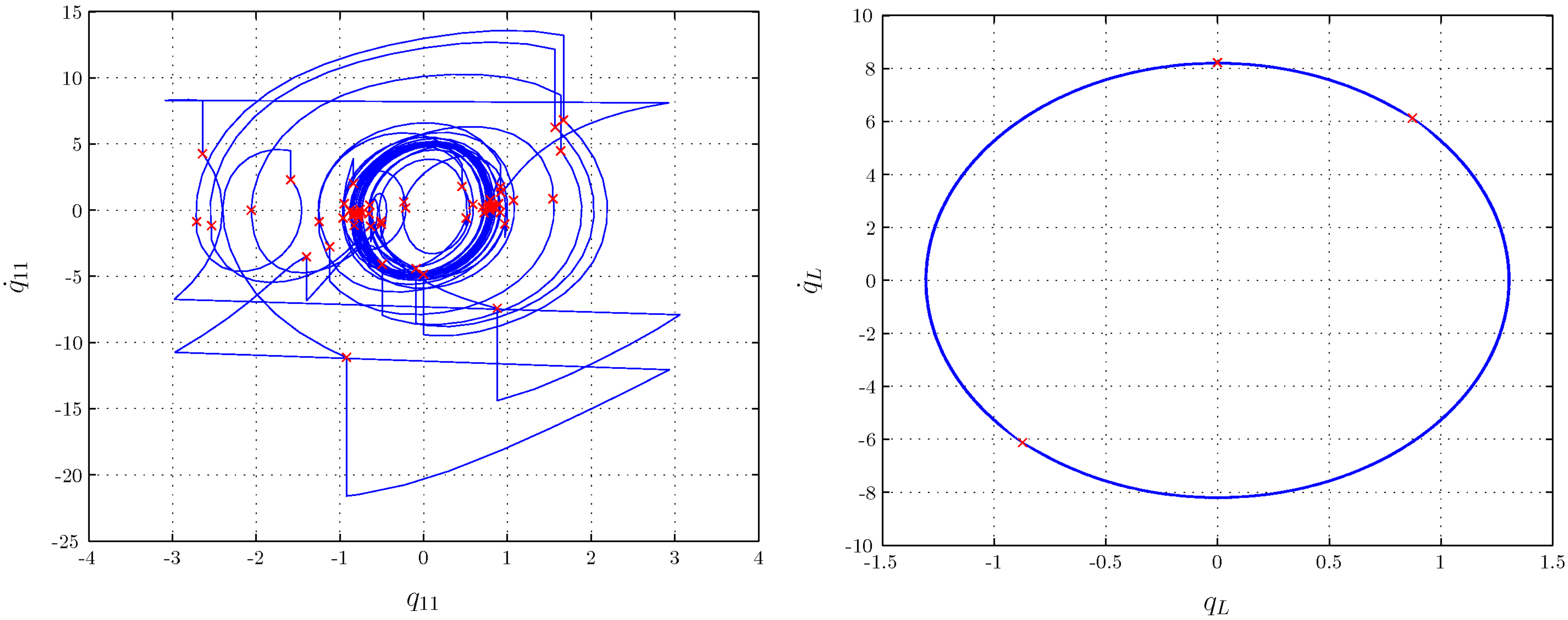




ROCR-1.00Hz-75deg-0.050b-50deg_sw-fix_steady_ss.mp4

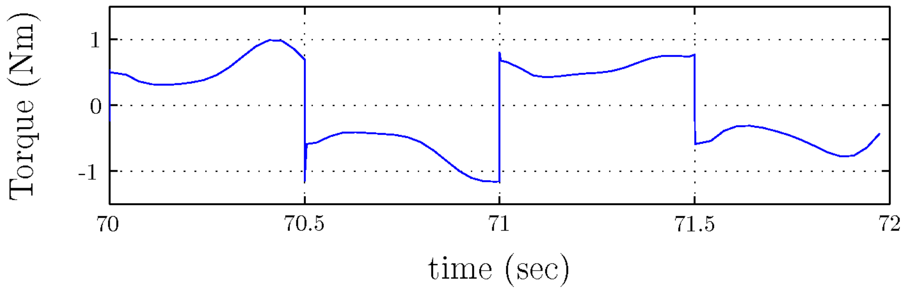
Trajectory-based control – High contact damping (30%)

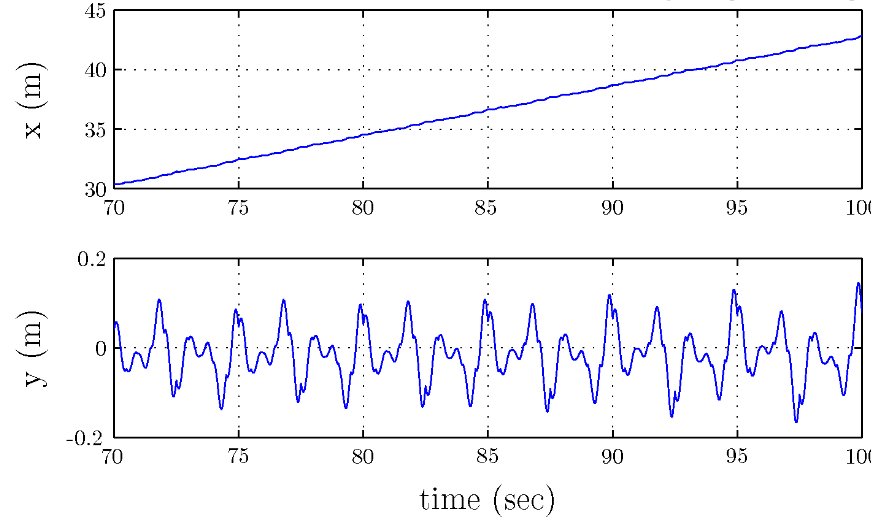
Decent settling to steady state after crazy initial start

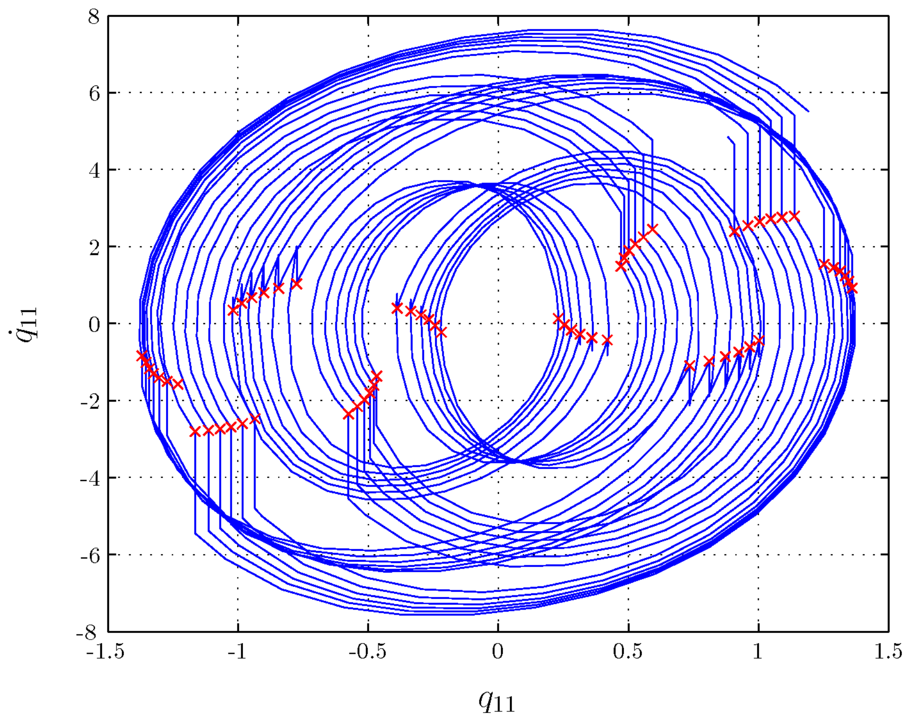


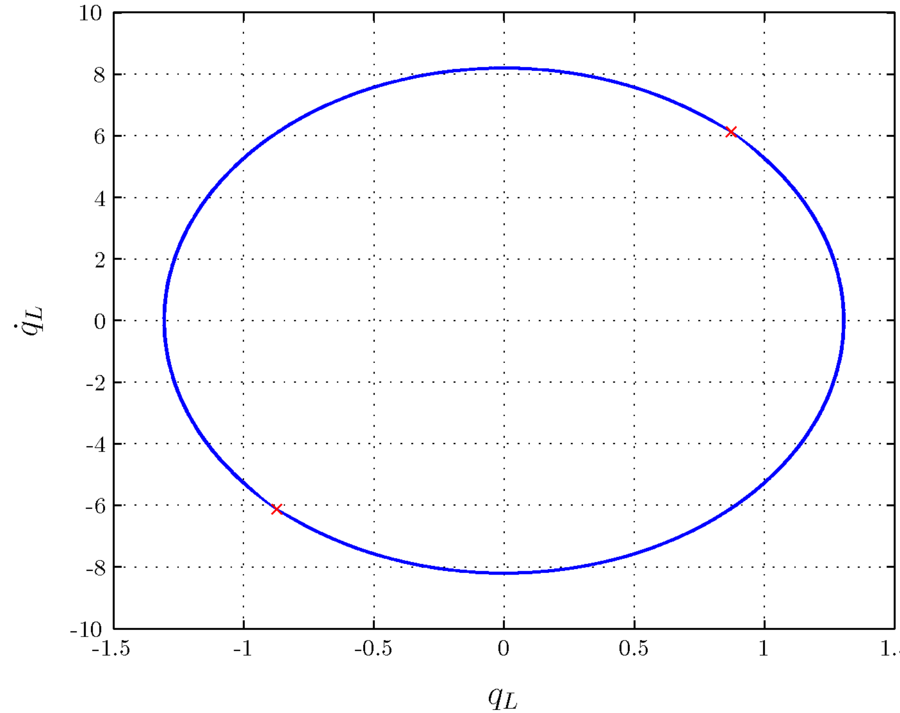
ROCR-1.00Hz-75deg-0.050b-50deg_sw-fix_init_ss.mp4

Trajectory-based control – Low contact damping (3%)





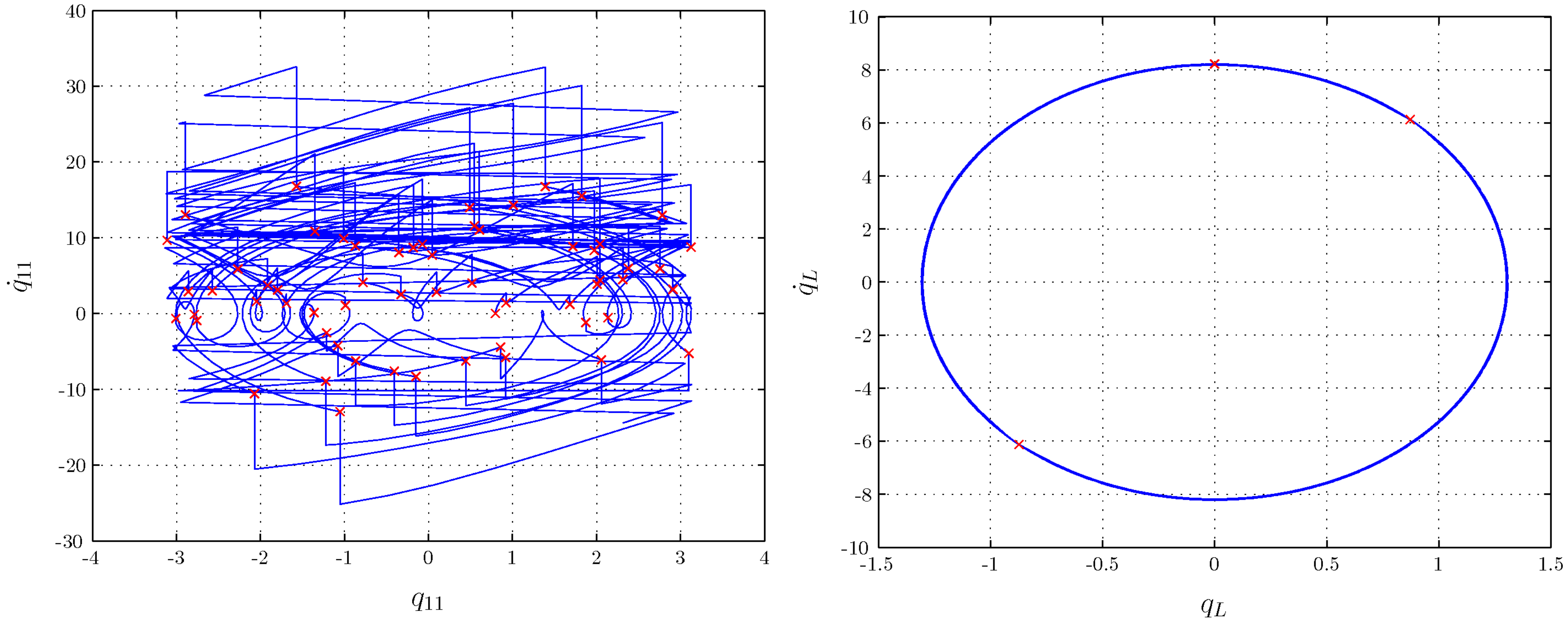




ROCR-1.00Hz-75deg-0.005b-50deg_sw-fix_steady_ss.mp4

Trajectory-based control – Low contact damping (3%)

No settling to steady state after crazy initial start



ROCR-1.00Hz-75deg-0.005b-50deg_sw-fix_init_ss.mp4

Chaotic hoppers provide some thoughts on further analysis

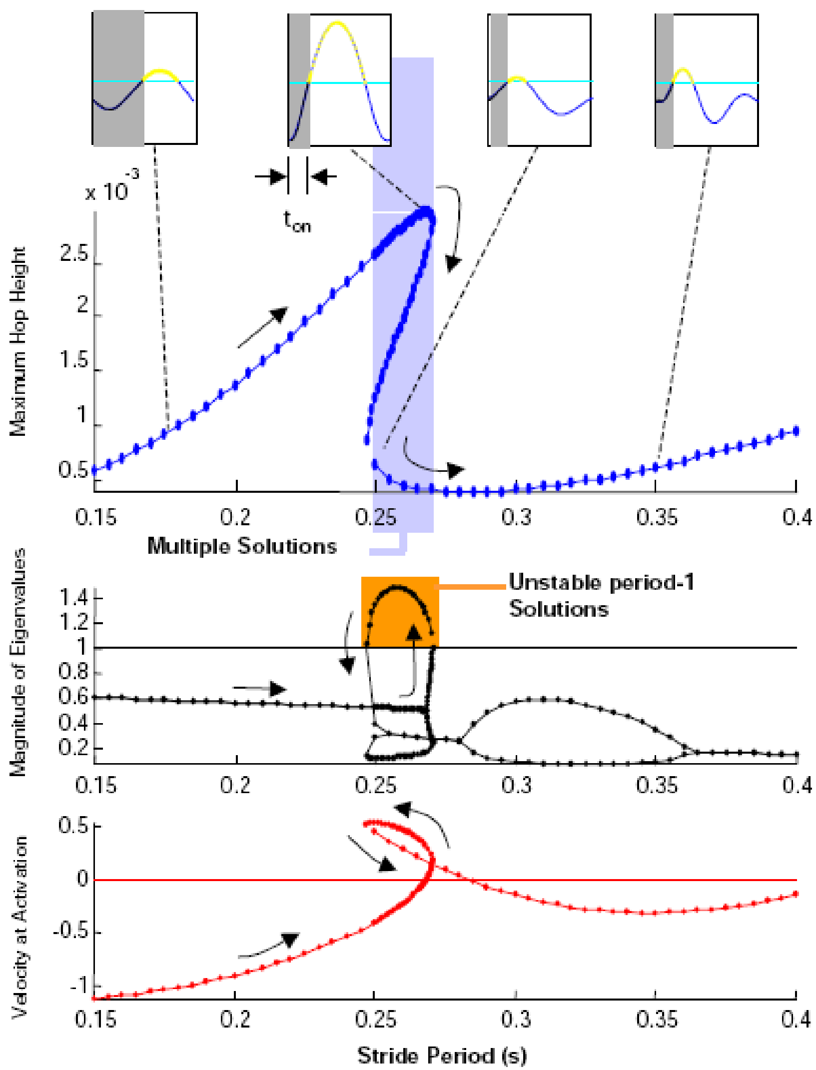
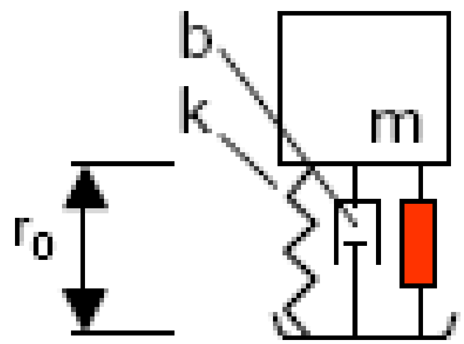
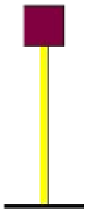


Figure 3-4. Steady-state solutions as a function of stride period for the 'Long Thrust" case. The arrows indicate how the continuum of solutions folds unto itself. The arrows also show how the continuum of the magnitude of the eigenvalues splits from two complex eigenvalues with the same magnitude to an unstable and a stable real eigenvalue.

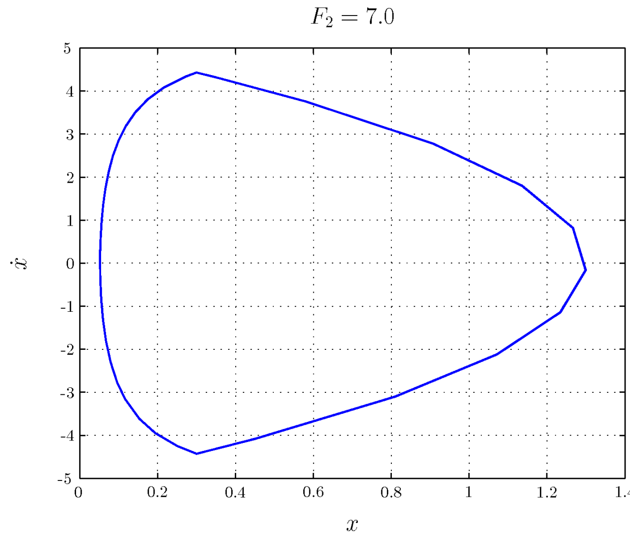


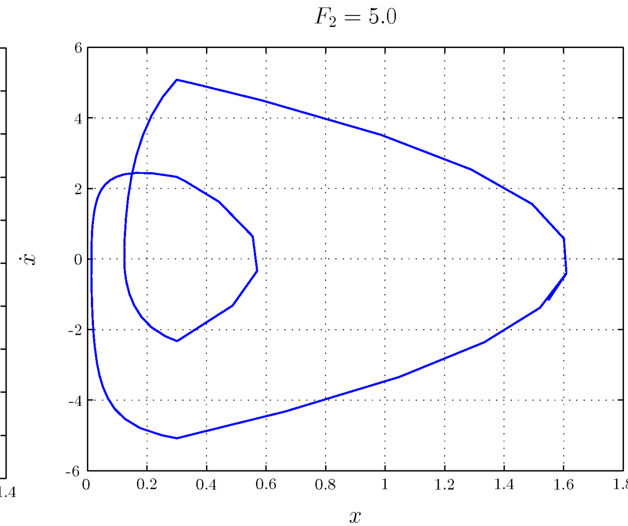
Jorge Cham, 2002

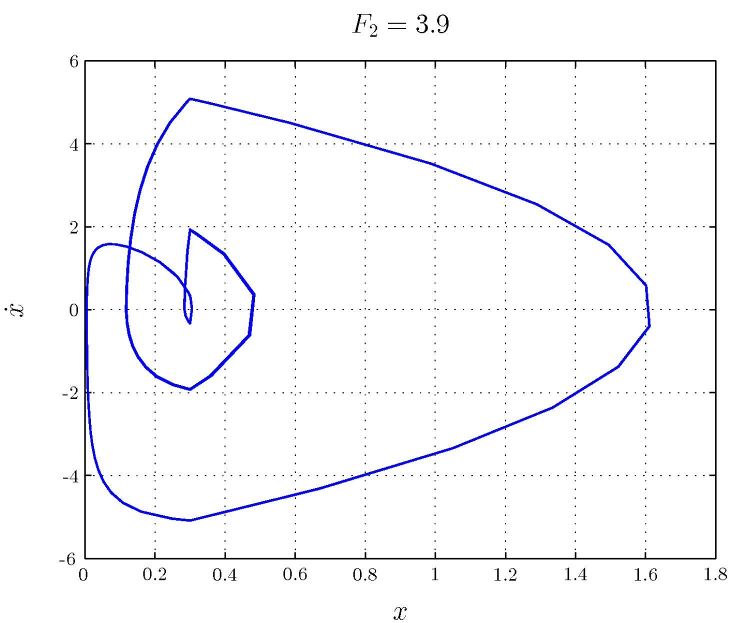
Hoppers may show chaotic behavior due to nonlinear dynamics and/or actuator timing

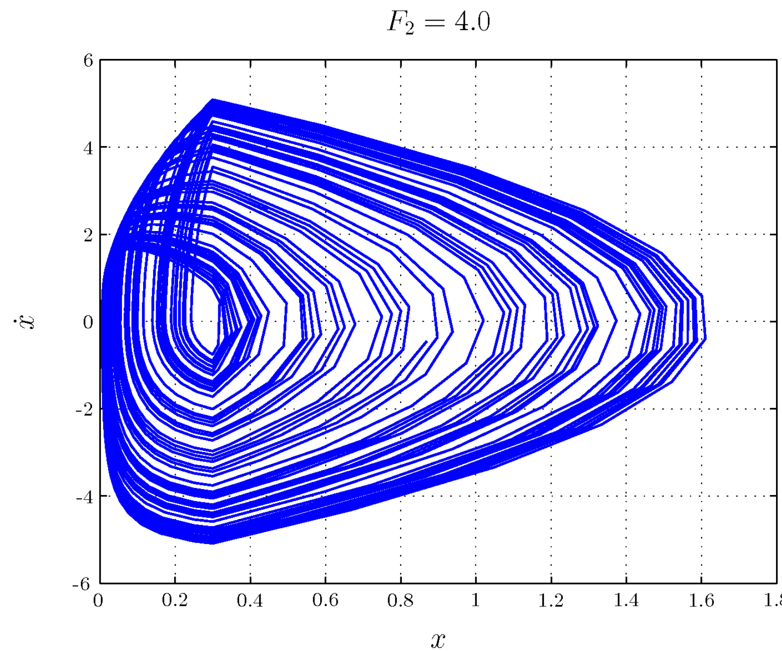


$$\ddot{x} = \frac{\eta_1}{mx} - g$$
$$\ddot{x} = \frac{F}{m} - g$$
$$\ddot{x} = \frac{F x_{et}}{mx} - g$$
$$\ddot{x} = -g$$









Koditscheck and Bühler, 1991
Vakakis, Burdick, and Caughey, 1991

Where next?

- Continue investigation into minimizing chaos
  - Switching – State based vs timed? Energy effects?
- Get back to optimization to find feasible trajectories

...and...