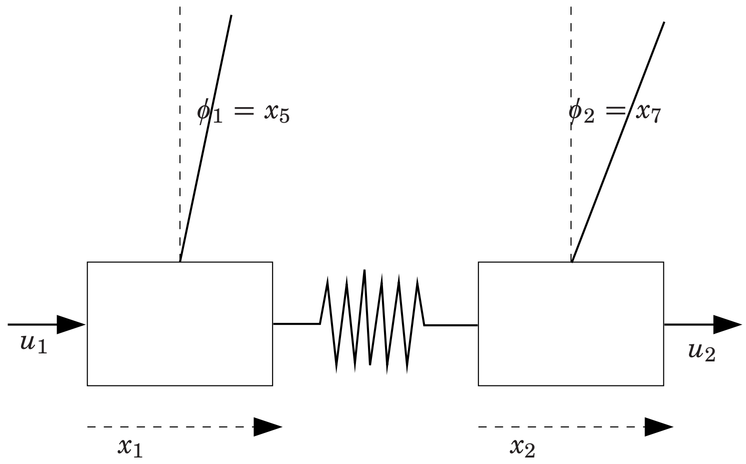
Handin 5 - Connected Inverted Pendulums (LQG)



The process consists of two inverted pendulums mounted on movable carts. The carts are connected with a spring. The inputs are the forces on the two carts. The outputs are the cart positions and pendulum angles. The system hence have 2 inputs and 4 outputs.

The system parameters correspond to 1m pendulums mounted on 1kg carts. Control signal $u = 1$ corresponds to a force of 10N. A spring deflection of 0.1m gives a spring force of 10N (i.e. $k = 100$). There is also a small viscous friction. The mass of the pendulums can be neglected.

Design specifications:

Design a LQG controller obtaining

- Stable, well damped closed loop system
- $M_s = \|(I + CP)^{-1}\|_\infty < 3$
- $M_t = \|(I + CP)^{-1}CP\|_\infty < 3$
- Settling time (to 10 % of peak) < 5 seconds for initial disturbance $x_1(0) = 0.05$ m. Max input signal $|u(t)| < 1$.
- Settling time (to 10 % of peak) < 5 seconds for initial disturbance $\phi_1(0) = 0.05$ rad. Max input signal $|u(t)| < 1$.
- Integral actions is not required.

It would be nice with better robustness margins, but it seems to be hard to get e.g. $M_t < 1.5$ without sacrificing other performance (try it if you have time).

Suggest a change of process parameter that would make better robustness margins feasible (pendulum lengths, cart masses, spring constant, viscous friction constant, . . . ?).

You can use the matlab-script pend.m to get started.