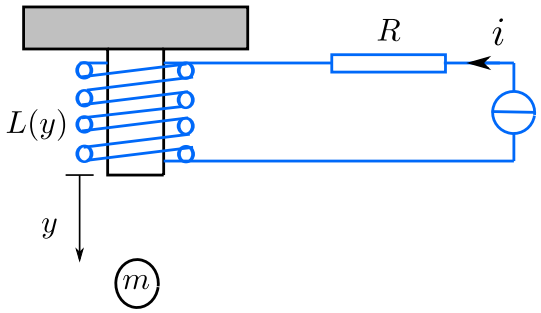
TD9 : Backstepping control of a magnetic levitation system

(State feedback stabilization)

Objective : Apply the backstepping control design to stabilize a nonlinear second order system.

Consider the following magnetic levitation system.



When a current i passes through the coil, a magnetic force $F = \frac{Ki^2}{y^2}$ is induced and applied on the ball. $K > 0$ is a constant. The coil is modeled by a resistance R and an inductance $L(y)$ (which depends on the airgap) but it is assumed that the current is regulated to a desired value we control.

1. Determine the differential equation modeling the system, and then the state-space representation with the state $x_1 = y$, $x_2 = \dot{y}$ and i being the control input.

2. For a given desired position y_0, what is the equilibrium point ?

3. Reformulate the state space representation in the error coordinate $e = x - x^*$.

4. Considering only the first equation (dynamic of e_1) and considering e_2 as the virtual control input, propose a simple control law that asymptotically stabilizes e_1 and provide a Lyapunov function $V_1(e_1)$.

5. Apply the backstepping method to design a stabilizing control law for the whole system.