Integration Project Systems and Control (SC42035)
Magnetic Manipulation (Magman) Experiment

Description

The magnetic manipulator (Magman) setup consists of four electromagnetic coils arranged linearly, with a spacing of 25 mm, see Fig. 1. By actively controlling the current through the coils, the magnetic field above them can be shaped to manipulate a steel ball ($m = 0.056$ kg). The control objective is to position/regulate the ball quickly, accurately, and without overshoot. This system has four control inputs $u_1, \ldots u_4$, which are the currents applied to the coils, ranging between 0 and 0.6 A. There is one measured output: y, the position of the ball given in meters.

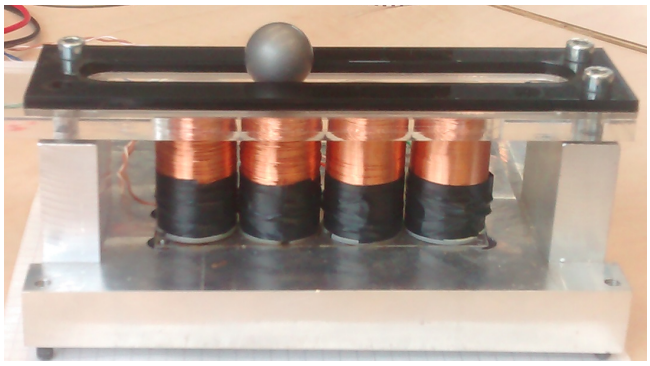

Figure 1: A photograph of the Magman setup.

The electromagnetic force exerted on the ball is a highly nonlinear and uncertain function of the electric current and the ball position. One possible analytical approximation of this function for a single coil is:

$$F(x, i) = g(x)\, i^2 = \frac{-\alpha\, x}{(x^2 + \beta)^3}\, i^2 \tag{1}$$

where x is the distance between the ball and the center of the coil, α and β are the dimensionless coil parameters, and i is the current through the coil. Students working with this setup are invited to propose creative ways to identify the parameters in the above function or even find a better approximation. A force measurement device can be borrowed from the Meetshop at 3mE.

Control Objective

Design a controller that makes the ball position follow a specified reference trajectory. The controlled system should have zero steady-state error and adequate disturbance rejection properties, i.e., it should be able to recover from a small tick against the ball.

Simulink Template

A Simulink template `magmantemplate` contains the necessary real-time interface blocks and some scopes. Make your own copy of this file (and other files in the same directory) and use it as a starting point for your experiments. Before starting the first simulation, define the sampling period h as a variable in the MATLAB workspace.

Note

Do not stare in the laser!