Exercise set 9 - Control

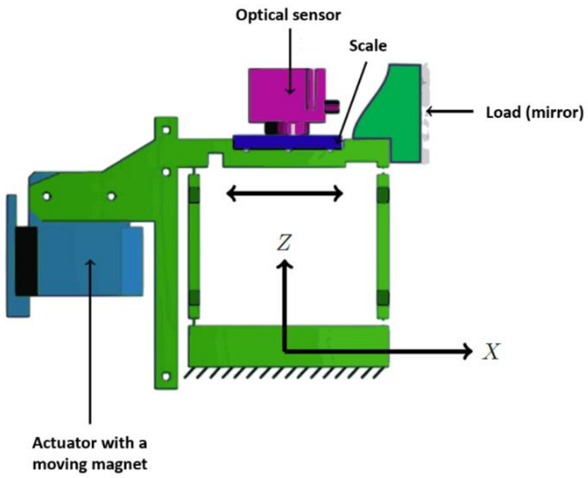
Exercise 1

Consider a motor with a torque constant k_t, a reducer with a reduction ratio $n = 32$ and an incremental encoder with 500 quadrature increments (i.e. 500×4 pulses per revolution). The motor is tuned with a PD position controller at a sampling rate of 1kHz. J_m and J_l are the respective moments of inertia of the motor and of the driven load.

1. Give the resolution in position (in degrees) at the load level.
2. The speed is obtained by numerical differentiation. Give the resolution in speed if we calculate the derivative over:
   (a) one sampling period.
   (b) two sampling periods.
3. The backlash of the reducer is approximately $0.1°$. Is this acceptable? If not, what can be done to solve the problem?
4. As a function of the controller gains K_p and T_d (according to the expressions in the course), determine the quantization noise on the control current.
5. Determine the smallest manageable displacement due to this calculated current resolution.
   Hint: Consider the relationship between input current and output position based on system dynamics.

Exercise 2

Consider the following flexure hinge-based guide actuated by a current-controlled DC motor.



Let:

- k_f be the force constant between the active generated force and the motor current.
- m_g be the equivalent mass of the flexure hinge guide.
- m_l be the mass of the load (mirror and support).
- k_s be the equivalent stiffness of the leaf spring hinges.

1. (a) Give the transfer function current - displacement.
   (b) Determine the shape of the position response to a current step.
2. The actuator is looped with a PD controller. Make a block diagram of the closed loop with this controller.
3. (a) Give the expression of the new closed loop transfer function.
   (b) Identify the meaning of each coefficient of this transfer function. (We'll consider a step input – we want to reach a constant desired position x_d, i.e. $\frac{dx_d}{dt} = 0$)