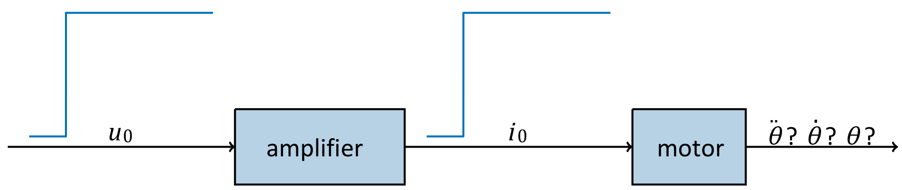
Exercise Set 8 - Electric actuators

Exercise 1

Consider a DC motor with:

- J_m the inertia of the motor.
- R_a the winding resistance.
- L_a the winding inductance.
- k_e the electrical constant
- k_t the torque constant

This motor is controlled in current by a voltage-current amplifier.



Give the shape of the acceleration, speed, and position curves at the output for a given step input i_0.

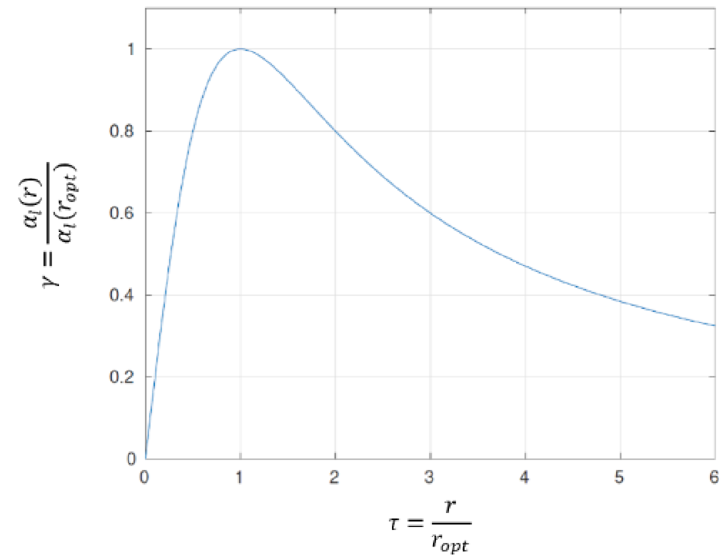
Hint: First derive the theoretical response to the given input. Later, derive the realistic response by taking into consideration that the amplifier's output voltage is limited by the supply voltage.

Exercise 2

The motor axis of the second rotation of a SCARA robot is produced by the combination of a motor and a reducer with the following specifications:

- motor inertia: J_m = 625 g.cm^2
- reduction ratio: n = 180
- inertia of the arm: J_a = 0.1 kg.m^2

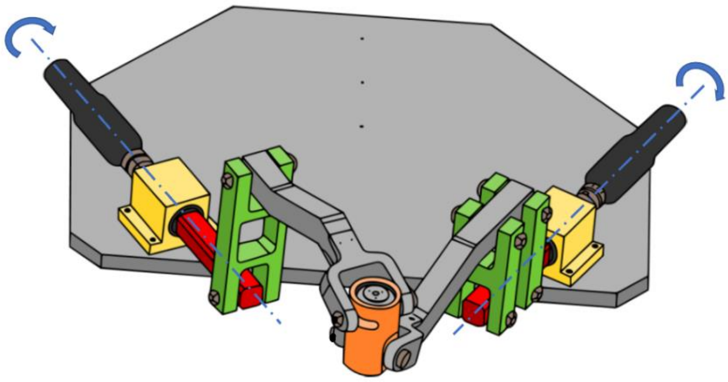
Here is the curve $\gamma(\tau) = \frac{\alpha_l}{\alpha_{opt}} = 2\frac{\tau}{1+\tau^2}$, where $\tau = \frac{r}{r_{opt}}$ with r – the reduction ratio and α – the acceleration.
(*l* stands for "load" and "opt" for "optimal")



1. Determine the optimal reduction ratio for the considered segment.
2. With the given transmission in the question, determine the achievable rate of acceleration in relation with the optimal case.

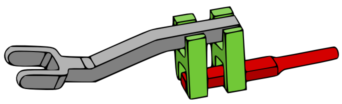
Exercise 3

Consider the robot shown below:

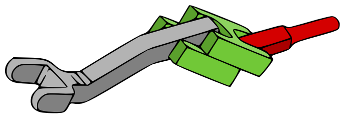


1. Give the type of architecture of the robot (serial or parallel).
2. Determine the number of DOFs.
3. Represent the vectors of the tool coordinates and the joint coordinates on the drawing.

One of the robot's "motor + reducer + arm + forearm" axes is shown below in two extreme postures. Each posture corresponds to a disposition of the robot and for each posture the equivalent inertia of the load (arm + forearm) is given by the value J_l.



(a) $J_l = 1.01 \times 10^{-1}$kg.m^2



(b) $J_l = 3.36 \times 10^{-2}$kg.m^2

Note: Although the geometry of the arms is not exactly the same on both sides, assume that they have the same equivalent inertia.

Knowing the following parameters:

- reduction ratio (GP62A): $n = 181$
- inertia of the reducer on the input side: $J_r = 88$ g.cm^2
- inertia of the motor (RE 50): $J_m = 542$ g.cm^2
- nominal motor torque: $\Gamma_m = 420$ mN.m

4. Give the equivalent moment of inertia referred to the output (load side).
5. Give the optimal reduction ratio for each configuration.
6. Are we too far from optimal performance?