Exercise Sheet 9: Open-loop Integrators

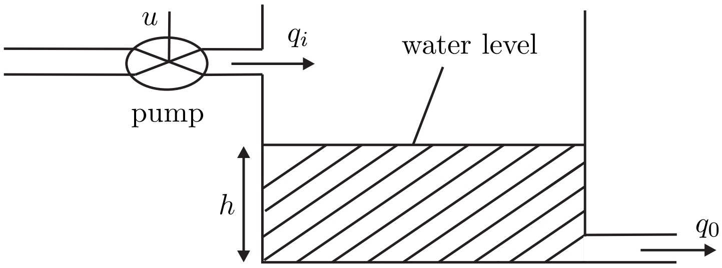
Problem 18:

We consider the *one-tank* system in the following figure. The tank with a surface area of A is connected to a pipe for inflow q_i [m^3/sec] and a pipe that leads to outflow q_o [m^3/sec]. That is, the height h of the water-level in the tank is described by the differential equation

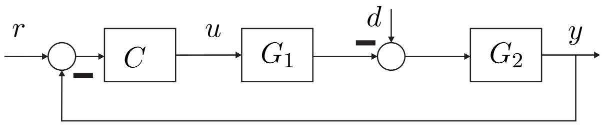
$$\dot{h} = \frac{1}{A}(q_i - q_o).$$

In addition, it is assumed that the water inflow is provided by a pump that is actuated by an input voltage u and that is characterized by the transfer function (from input u to inflow q_i)

$$\frac{Q_i(s)}{U(s)} = G_1(s) = \frac{K_1}{1 + sT_1}$$



The plant can be represented by the following block diagram with the transfer functions $G_1(s) = \frac{K_1}{1 + sT_1}$ and $G_2(s) = \frac{1}{sA}$. The parameters are $A = .1\,\mathrm{m}^2$, $T_1 = 3\,\mathrm{sec}$ and $K_1 = 0.03\,\mathrm{m}^3/\mathrm{sec/V}$.



a. Assume that $C(s) = \frac{P(s)}{L(s)}$ such that $L(0) \neq 0$. Show that it holds for disturbance steps that $\lim_{t\to\infty} e(t) \neq 0$.

We now investigate this feedback loop further for $L(s) = s^i L'(s)$ with $L'(0) \neq 0$.

b. Which value of i do you need such that disturbance steps are canceled for large times?

c. Which value of i do you need such that disturbance ramps are canceled for large times?

d. Assume you choose i as computed in **c.** Is there overshoot for disturbance steps?

Problem 19:

We consider the one-tank system in Problem 18.

a. Assume the controller $C(s) = 0.5$ is given. Realize the feedback loop in Simulink and confirm the result in Problem 18 **a.** by simulation.

b. Assume that the controller $C(s) = 0.5\frac{1 + 10\,s}{s}$ is given and confirm the result in Problem 18 **b.** by simulation.

c. Assume that the controller $C(s) = \frac{1}{1000}\frac{(1 + 50\,s)^2}{s^2}$ is given and confirm the results in Problem 18 **c.** and **d.**