Lab 3 Post-Lab

Report Assignments

Complete these assignments during the lab. *Show all work for credit.*

1. In the experiment on the leaking tank, you engineered the system to correspond to a particular flow rate $q_{in}(t)$ and initial value $h(0)$, and then used your knowledge of the response $h(t)$ to estimate T. Describe $q_{in}(t)$ and $h(t)$ using the appropriate terminology.
2. Record your measured and estimated values of h_{bottom}, h_{top}, V_{bottom}, V_{top}, a, b, and T with the appropriate units.
3. Use a measurement of the cross-sectional area A and the value $9.81\ \text{m/s}^2$ for the acceleration of gravity to estimate the resistance R across the outlet and record this with the appropriate unit.
4. Plot the theoretical and experimental height data versus time.
5. Critically evaluate the assumptions made in modeling the leaking tank as a linear, first order system over a large range of water levels.

1).

$$\because A\dot{h}(t) + \frac{g}{R}h(t) = q_{in}(t) = 0$$

$$\therefore h(t) = h(0)\, e^{-\frac{g}{AR}t}$$

$$h(t) = a V(t) + b$$

$$A = 0.113 \times 0.18\ m^2 = 0.0203\ m^2$$

2). Measured data:

$h_{bottom} = 0.01611\ m$

$h_{top} = 0.1165\ m$

$V_{bottom} = 1.185\ V$

$V_{top} = 2.358\ V$

$a = 0.0856\ m/V$

$b = -0.08531\ m$

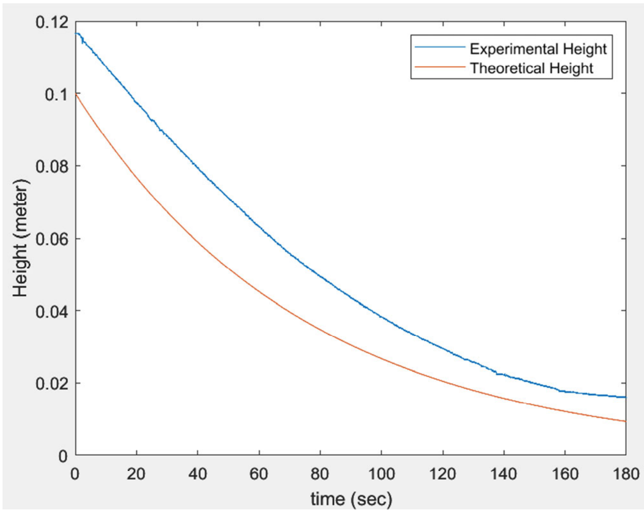
$T = 91\ s$

3).

$$\because \frac{AR}{g} = T$$

$$\therefore R = \frac{gT}{A} = \frac{9.81 \times 91}{0.0203} = 43976\ 1/ms$$

4).



5). The main trend of the model curve and the real curve are the same. But the y intersection is different.

6. In the experiment on the hydraulic motor, you engineered the system to correspond to a particular command input $u(t)$ and initial value $x(0)$, and then used your knowledge of the response $x(t)$ to estimate T. Describe $u(t)$ and $x(t)$ using the appropriate terminology.

7. Record your estimated values of T and K for each of the three step inputs with the appropriate units.

8. Estimate the delay between the step input in the command signal and the system response. What is a possible source of this delay? Does it affect your estimates of T and K?

9. Use the experimental data to critically evaluate the assumption that the hydraulic motor can be modeled as a linear, first order system over a large range of inputs.

6). $T\dot{x}(t) + x(t) = k \cdot u(t)$

Characteristic function:

$$T\lambda + 1 = 0$$

$$\lambda = -\frac{1}{T}$$

$\therefore x_h(t) = e^{-\frac{1}{T}t}$

$\because x_p(t) = c \quad \therefore c = k \cdot u(t)$

$\therefore x(t) = C_0 e^{-\frac{1}{T}t} + k \cdot u(t)$

$\because x(0) = 0$

$\therefore x(t) = k \cdot u(t) \cdot (1 - e^{-\frac{1}{T}t})$

$\therefore t \to \infty,\ x(t) \to k \cdot u(t)$

$t = T,\ x(T) = k \cdot u(t) \cdot (1 - e^{-1})$

$\approx 0.63\ k \cdot u(t) = 0.63 \cdot x(\infty)$

7).
8).

① $u(t) = 1V$

$K = 315$ RPM/V

$T = 0.073$ s

delay ≈ 0.066 s

② $u(t) = 1.5V$

$K = 296.67$ RPM/V

$T = 0.07$s

delay ≈ 0.058 s

③ $u(t) = 2V$

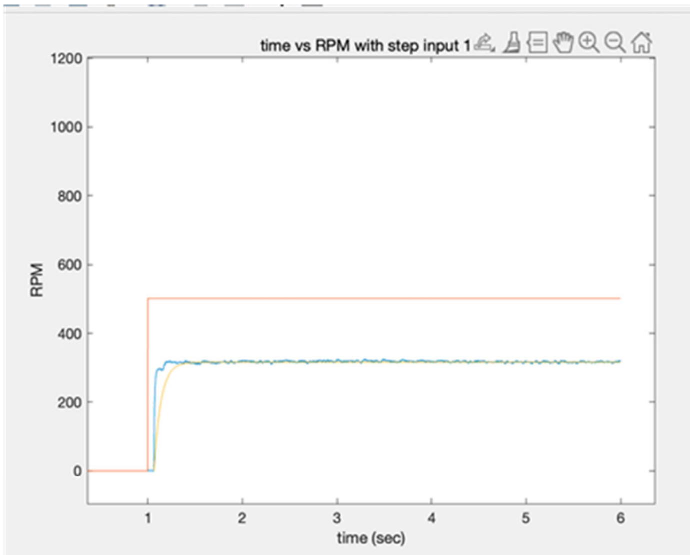
$K = 275$ RPM/s

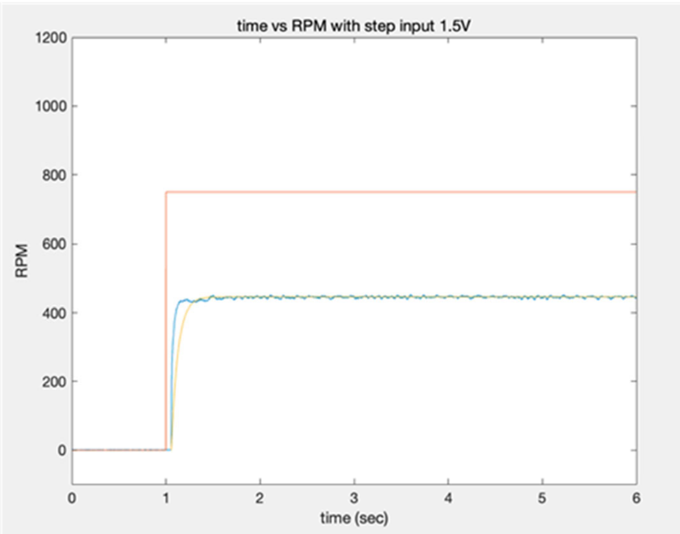
$T = 0.071$ s

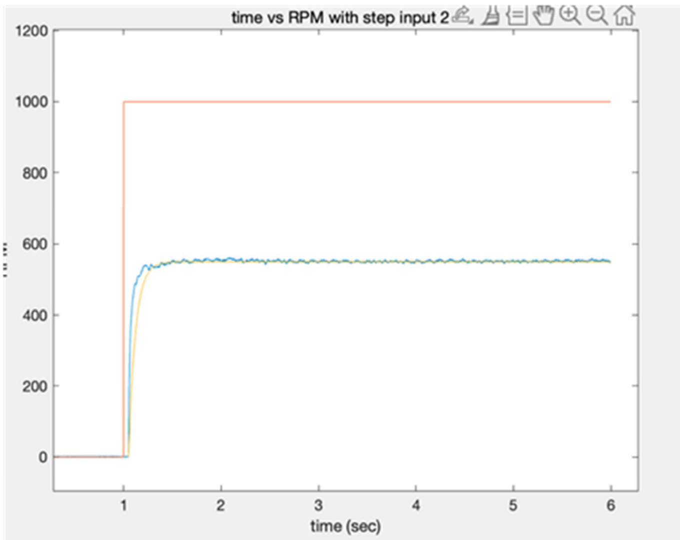
delay ≈ 0.052 s

Because it's hydraulic motor which is driven by liquid. Therefore, to move the liquid in the pipe will take time, which lead to this delay. The longer the pipe is, the longer delay it would have, I think.

9).







From these 3 plots we can see the measured data is generally the same as the theorical value. Therefore, using linear first order system for $u(t) \in [1, 2]$ is appropriate. But when having too large input, the error might increase a lot.