MISR UNIVERSITY FOR SCIENCE AND TECHNOLOGY
COLLEGE OF ENGINEERING
MECHATRONICS DEPARTMENT

MTE 506 DIGITAL CONTROL

LAB 1 – SPRING 2019

Lab 1

Goals of The Lab

Discretization of Analog Control Systems

- Assertion on the notion of modeling and simulation
- Converting a dynamic system to mathematical model

Lab 1

Software For Simulation

Needed for all labs

MATLAB

R2017b or above

Student must install software in advance before attending any lab

Lab 1

Simulating Water Tank

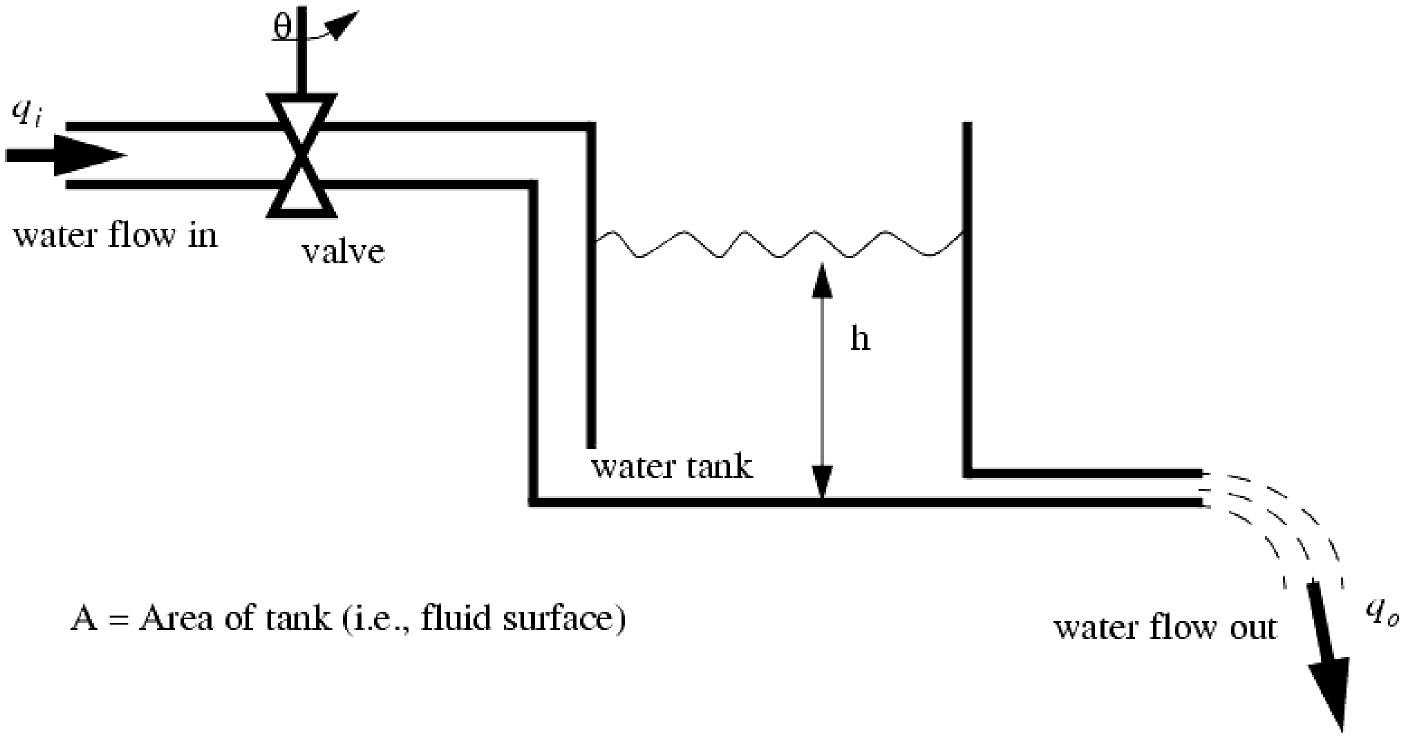
From physical simulation to modeling

Simulating behavior

Using MATLAB script for simulation

Mathematical Modeling

Using Simulink for implementing tank response



Lab 1

Quick review on concepts

Mechatronics notation

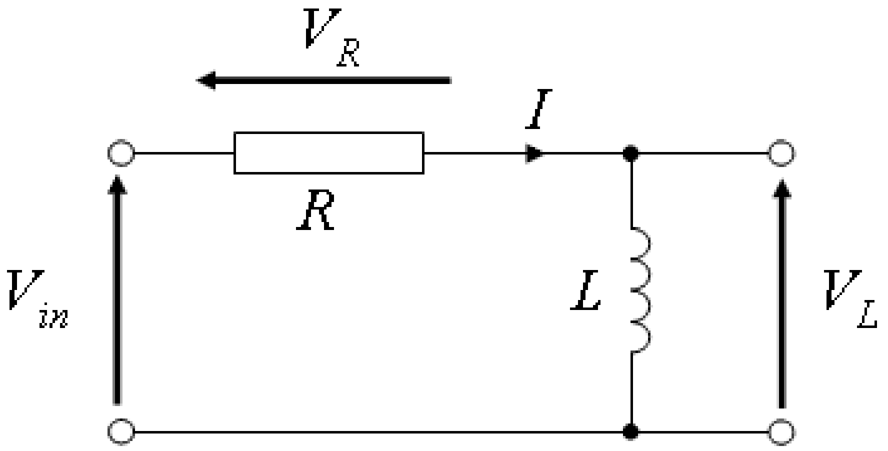
Modeling

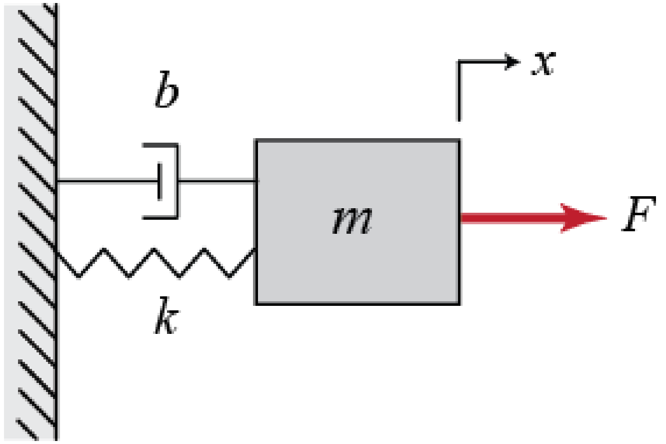
Converting behavior of objects into mathematical equations stating the relationship of system input(s) and output(s)

Examples

Mechanical : $m\ddot{x}(t) + \ c\dot{x}(t) + kx(t) = f(t)$

Electrical : $L\acute{i}\,(t) + Ri(t) = v(t)$





Lab 1

Quick review on concepts

Mechatronics notation

Modeling

Converting behavior of objects into mathematical equations stating the relationship of system input(s) and output(s)

Examples

Mechanical : $m\ddot{x}(t) + \ c\dot{x}(t) + kx(t) = f(t)$

Electrical : $L\acute{i}\ (t) + Ri(t) = v(t)$

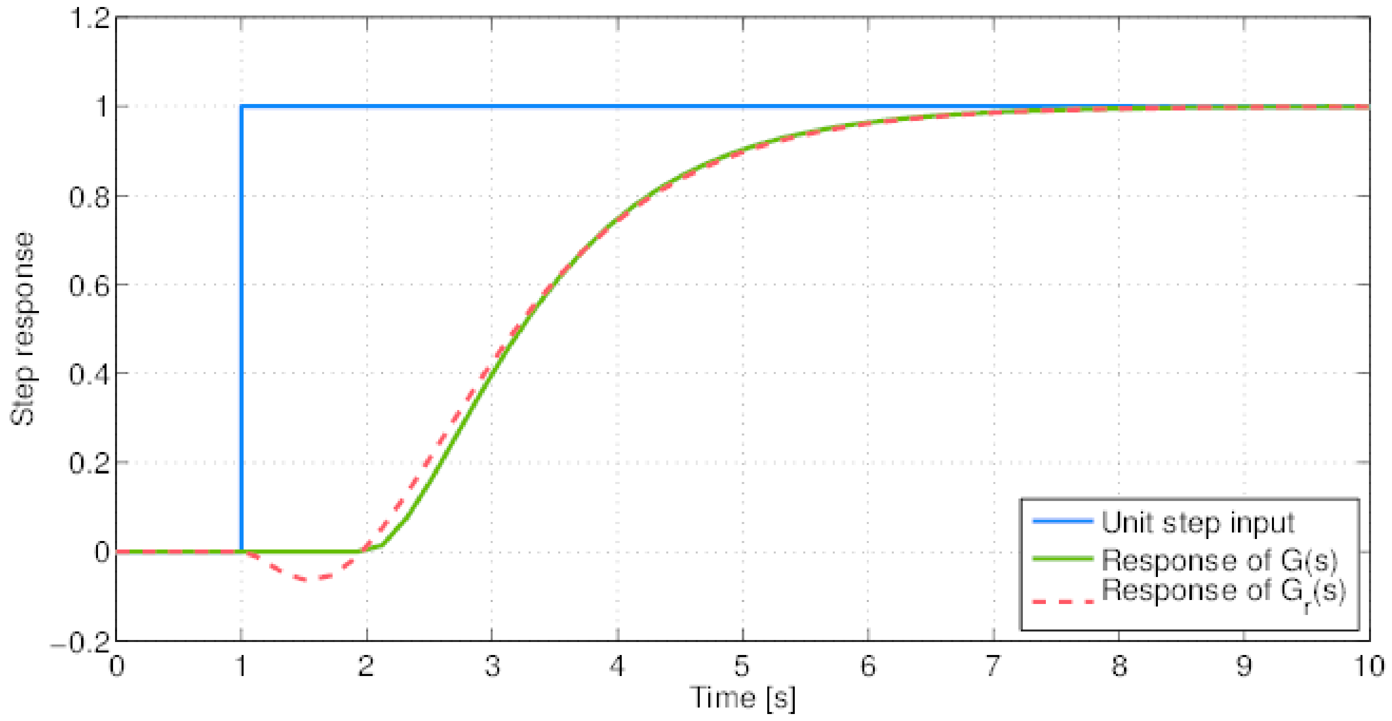
TRANSFER FUNCTION

Quick review on concepts

Mechatronics notation

Simulation

Plotting the output(s) when the model is stimulated by an input

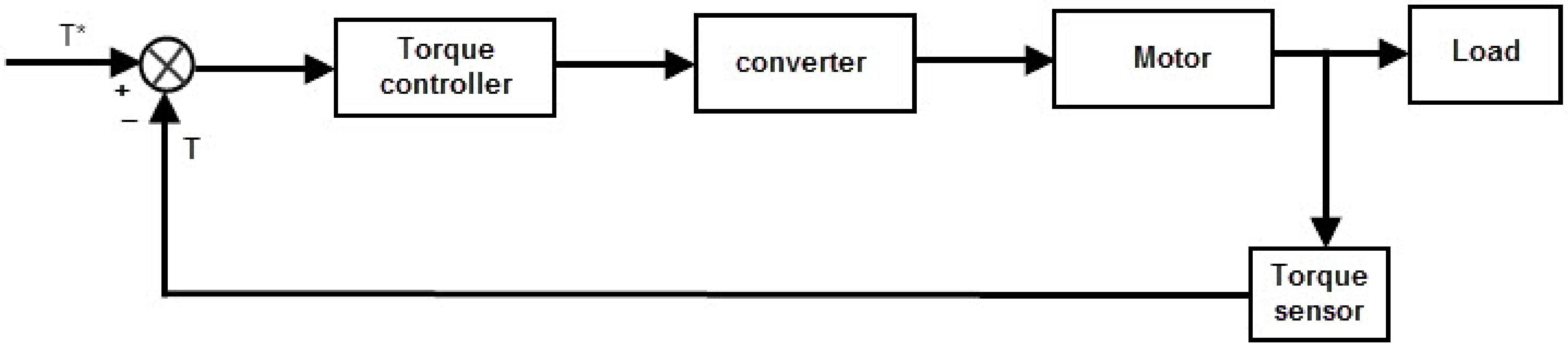


Quick review on concepts

Mechatronics notation

Control

Forcing an output to reach a desired level based on knowing the error in reading and desired input



Lab 1

Modeling of the tank

Simple example

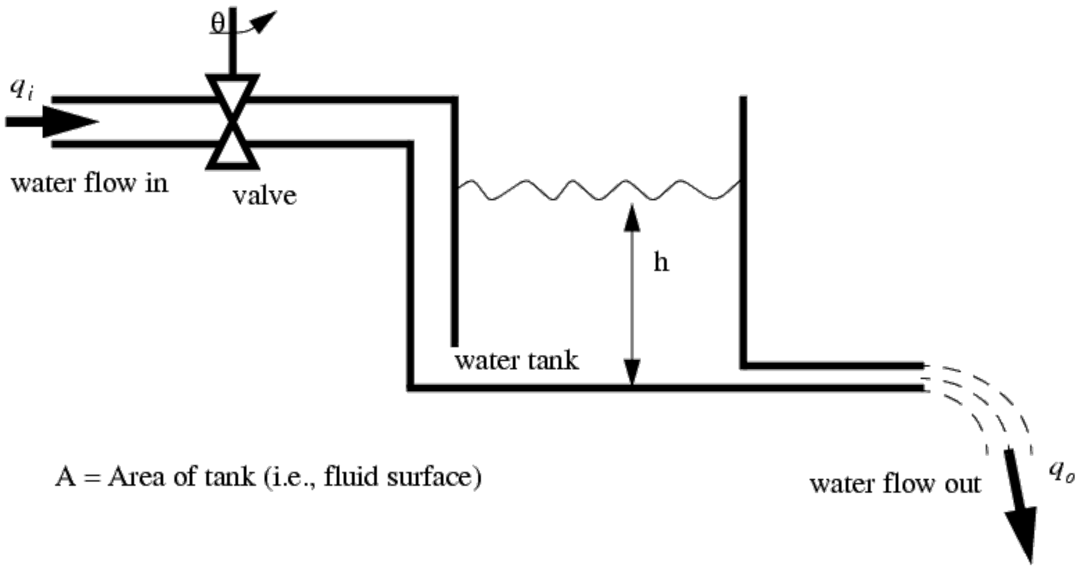
$We\ will\ ignore\ input\ valve\ (for\ simplification)$

$$\Delta V = q_o - q_i$$

$$A\frac{h(t) - h(t - \Delta t)}{t - (t - \Delta t)} = q_o - q_i$$

$$q_o = kh(t - \Delta t)$$

$$h(t) = \frac{\Delta t * (kh(t - \Delta t) - q_i)}{A} + h(t - \Delta t)$$



Lab 1

Modeling of the tank

Simple example

$$\Delta V = q_i - q_o$$

$$A\frac{h(t) - h(t-\Delta t)}{t - (t - \Delta t)} = q_i - q_o$$

$$q_o = kh(t - \Delta t)$$

$$\boxed{h(t)} = \boxed{\frac{\Delta t * (q_o - q_i)}{A}} + \boxed{h(t - \Delta t)}$$

dh

Previous State

q_i ...*Tank input flowrate* $(\frac{m^3}{s})$

q_o ...*Tank output flowrate* $(\frac{m^3}{s})$

h ...*Tank height* (m)

A ...*Tank cross sectional area* (m^2)

K ...*Output valve friction*

Lab 1

MATLAB scripting

Exercise 1

- What is the value of qin to reach a level of 3m ?
- Will the final level be changed if K is changed ?

Editor - D:\University\MTE 506 Digital Control\Lab 1\Exercises\Exercise 1\tank_simulation.m

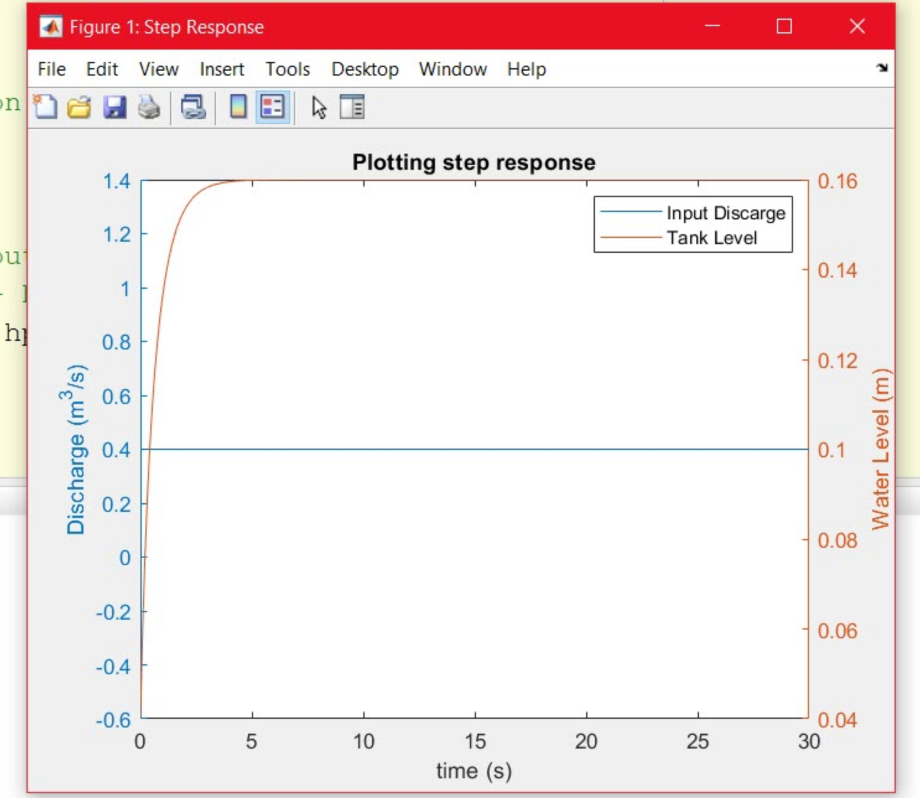
tank_simulation.m

```
%% Simulate the tank model
qin = 0.4 * ones([1 length(t)]); % convert qin single value to array
h = zeros([1 length(t)]); %allocate h values with zeros
for i = 1 : length(t)
    if (i == 1)
        hprev = h0; %initial condition
    else
        hprev = h(i-1); %h(t - dt)
    end
    qout = k * abs(sqrt(hprev)); % qou
    % h(t) = [(qout - qin(t))/area] + h
    h(i)= dt *( (qin(i) - qout)/a) + hp
end

figure('name','Step Response')
```

Command Window

```
>> tank_simulation
>>
```



Lab 1

Modeling of the tank

Laplace Transform

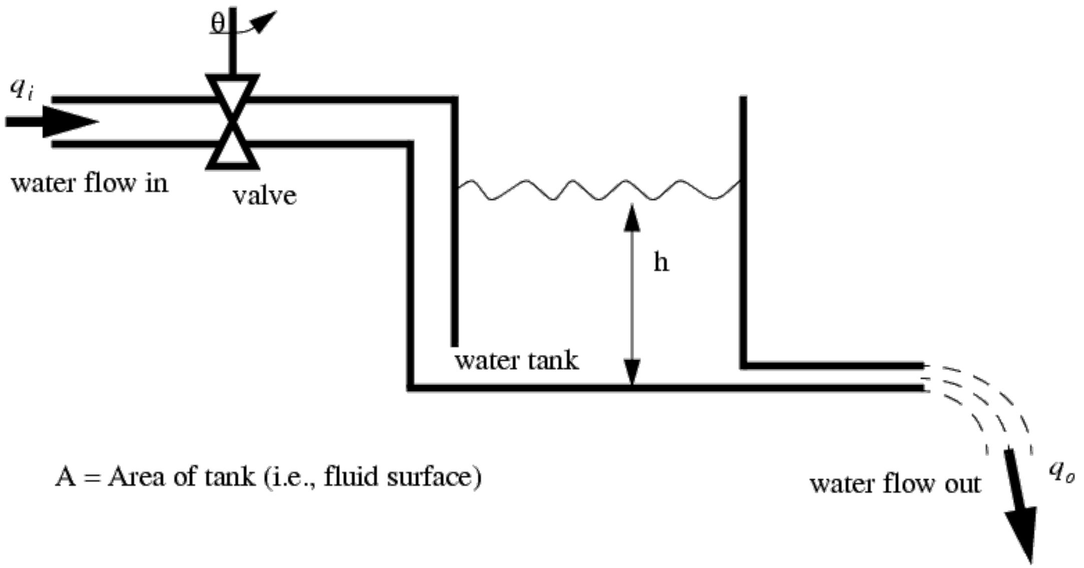
$We\ will\ ignore\ input\ valve\ (for\ simplification)$

$$\Delta V = q_i - q_o$$

$$A\frac{h(t) - h(t-\Delta t)}{t-(t-\Delta t)} = q_i - q_o$$

$$A\frac{dh}{dt} = q_i - kh$$

$$A\frac{dh}{dt} + kh = q_i \qquad \frac{A}{k}\frac{dh}{dt} + h = \frac{q_i}{k} \qquad \tau\frac{dh}{dt} + h = K_2 q_i$$



Lab 1

Modeling of the tank

Laplace Transform

$$\tau = \frac{A}{k} \qquad K_2 = \frac{1}{k}$$

$$\Delta V = q_i - q_o$$

$$A\frac{h(t) - h(t - \Delta t)}{t - (t - \Delta t)} = q_i - q_o$$

$$\frac{\boldsymbol{H(s)}}{\boldsymbol{Q_i(s)}} = \frac{\boldsymbol{K_2}}{\boldsymbol{\tau S + 1}}$$

$$A\frac{dh}{dt} = q_i - kh$$

First Order System

$$A\frac{dh}{dt} + kh = q_i \qquad \frac{A}{k}\frac{dh}{dt} + h = \frac{q_i}{k}$$

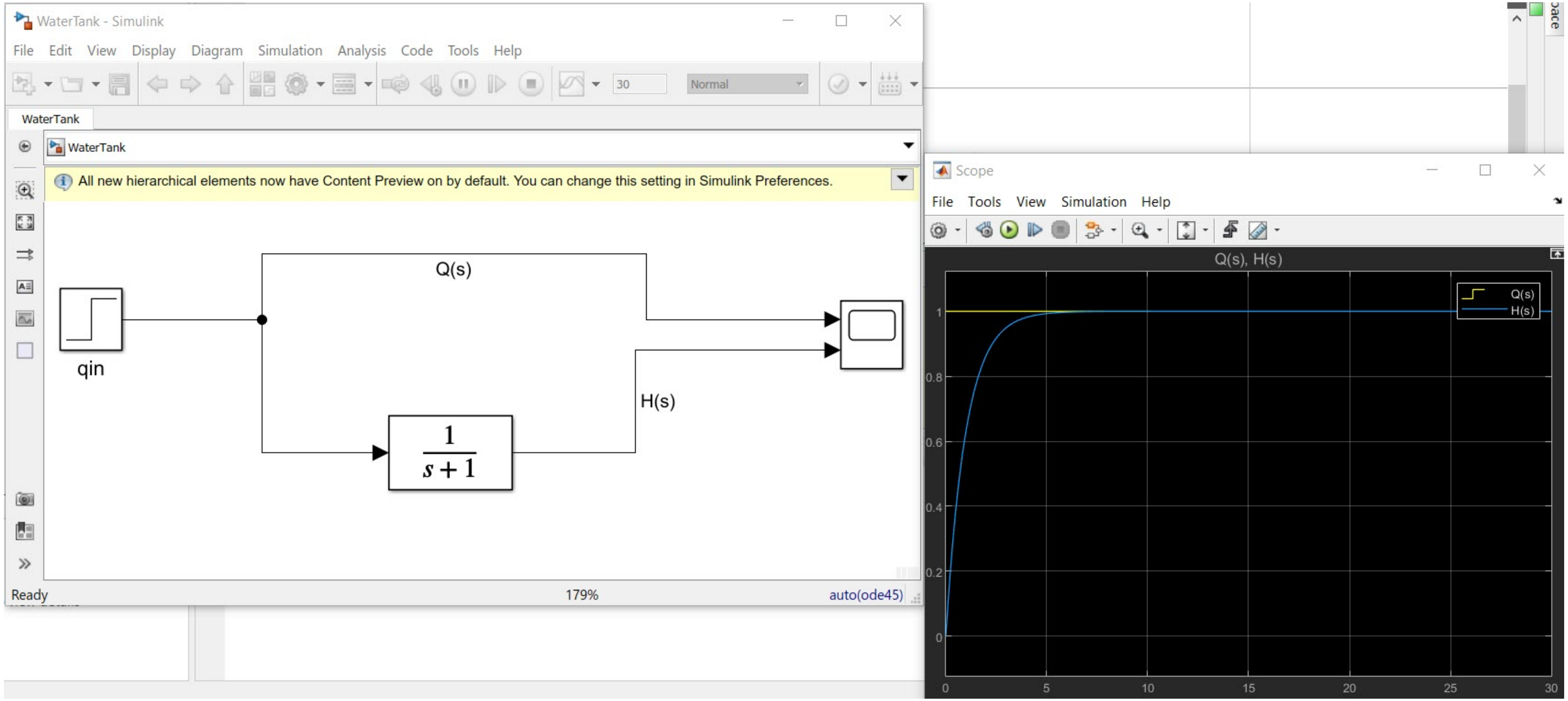
$$\tau\frac{dh}{dt} + h = K_2 q_i$$

Lab 1

SIMULINK

Exercise 2

- What is the value of qin to reach a level of 3m ?
- Will the final level be changed if K is changed ?



Please fill in your

Full Name, ID, Email address and **GitHub** handle to be able to get lab notes and exercises.

http://bit.ly/MTE506s2019

END OF LAB 1