Question 1

1. Use the PI(D) controller. What happens to the stability of the control system if the process time-delay is relatively large?

When change the time delay from 30 to 300, I observed a very unstable Temp\_meas, the curve go to the highest value then drop down quickly.

1. Use the PI(D) controller. Include random temperature measurement noise with max amplitude of 0.2 deg C. The D-term of the controller can be activated by increasing Td from 0 to one quarter of the integral time (Ti), which is the ratio between Td and Ti according to Ziegler and Nichols. Compare the behaviour of the control signal using PI controller and PID controller. With PID controller, select a filter time-constant so that you become content with the noise level in the control signal.

If increase Td from 0 to one quarter of the integral time (Ti), I saw the control signal presents a strong fluctuation, range from 20-80, the Temp\_meas value is no longer a horizontal line, it becames a line with small fluctuations around 40.

1. Use the On/off controller. Is the mean value of the control error zero or non-zero?

The mean value of the control error is zero.

Question 2

1. Derive the transfer function, H(s), from force F to position y.

We have D=4, k=2 and m=20

According to equations:

After transformation:

Replace x2 with x1:

So that we have:

1. Try to replicate the responses shown in Figure 2.8 in the textbook by using the lsim function in Matlab.

The matlab code is:

clear

clc

%define parameters

d = 4;

k = 2;

m = 20;

%define matrix

A = [0, 1; -(k/m), -(d/m)];

B = [0; 1/m];

C = [1, 0];

D = [0];

T = 0:0.01:50; %simulation time steps

U = zeros(size(T)); %define the input values

U(500:end) = 4; %from time step 5, the input value change from 0 to 4

X0 = [0 0]; %initial values

sys = ss(A,B,C,D); %define state space model

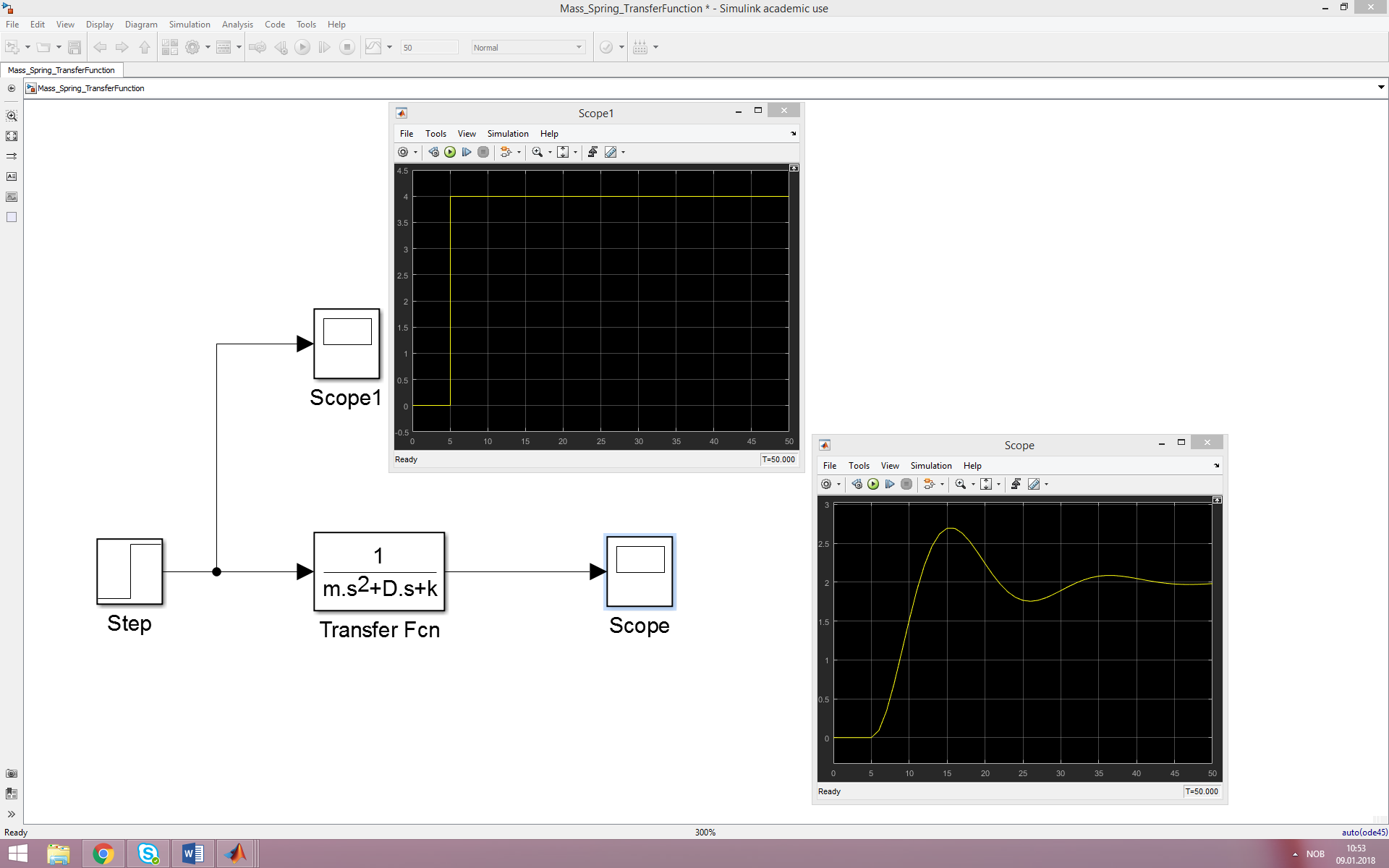
lsim(sys, U, T, X0) %simulate using lsim function

The simulation result:



1. Implement a simulator of H(s) in Simulink, and try again to replicate the responses shown in Figure 2.8 in the textbook. The simulation should be run using the simfunction in a Matlab script. Also in that script, the model parameters should be defined

The screen shot of Simulink:



The matlab code is:

%model parameters

m=20; %

D=4; %

k=2; %

t\_step\_F=5; %

F\_0=0; %

F\_1=4; %

%simulator

t\_stop=50; %

T\_s=t\_stop/1000; %

options=simset('solver','ode5','fixedstep',T\_s);

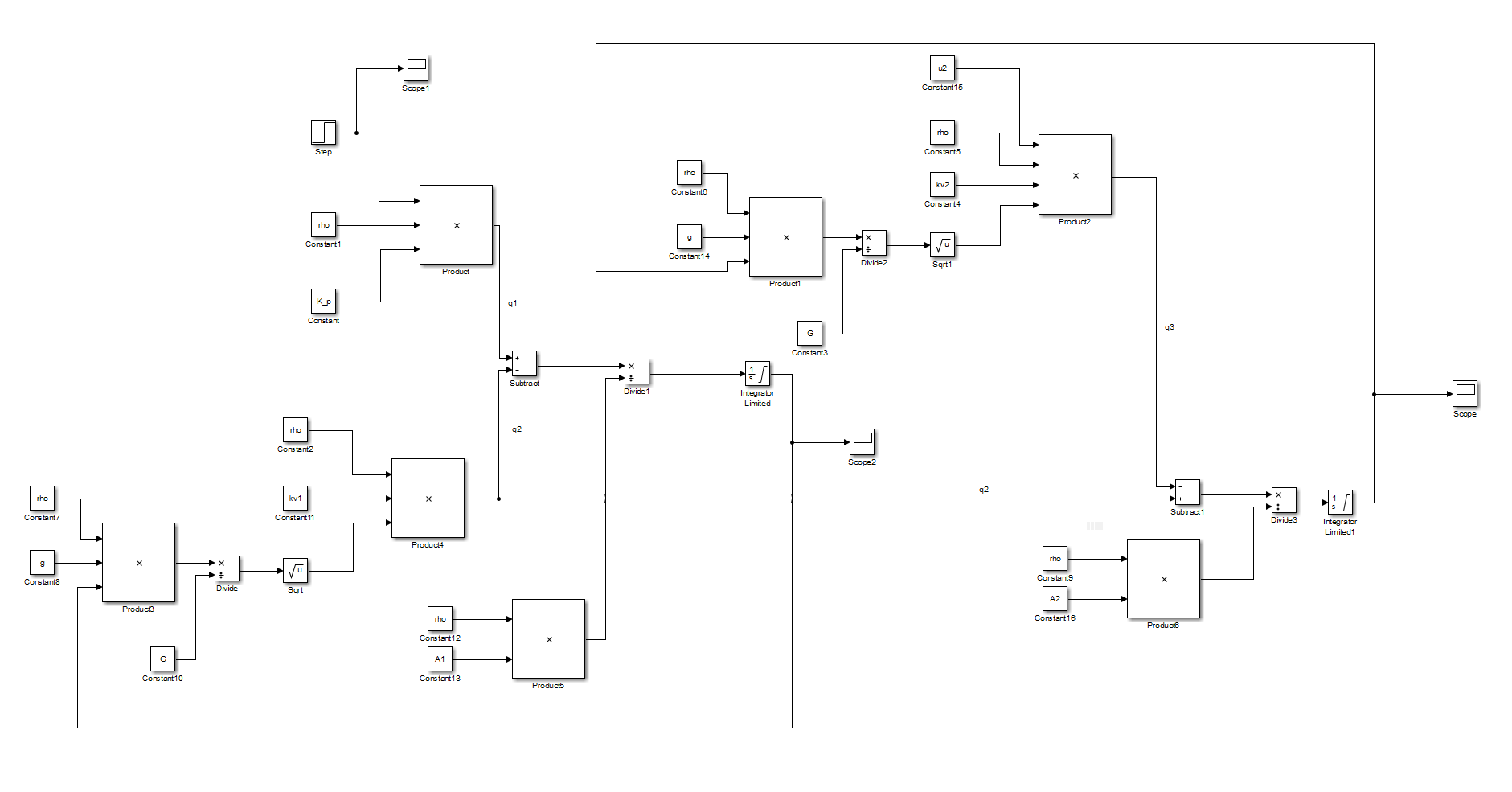
%starting simulation

sim('Mass\_Spring\_TransferFunction',t\_stop,options)

Question 3

1. Implement a simulator of the system in Simulink using a fixed-step solver

The screen shot of simulink:



Simulink files can be found in the ‘Valve\_Pump.slx’ file in the email attachment.

1. Run a simulation where u2 is kept constant, while u1 is changed as a step from zero to a proper nonzero value at some point of time larger than zero.

The matlab code is:

%model parameters

rho = 10; % density of water

g=10; % gravity

G=1; %

kv1=2; %

kv2=3;

K\_p=1; %

A1=10; % area of tank1

h\_upper=2; %upper saturation limit of tank

h\_lower=0; %lower saturation limit of tank

u2=2;

A2=10; % area of tank2

t\_step\_F=10; %

F\_0=0; %

F\_1=20; %

%simulator

t\_stop=100; %

T\_s=t\_stop/1000; %

options=simset('solver','ode1','fixedstep',T\_s);

%starting simulation

sim('Valve\_Pump',t\_stop,options)

u1 value:



h1 value (level of tank 1)



h2 value (level of tank 2)



1. Verify that the simulated levels are equal to the analytically calculated levels under steady-state (static) conditions.

Parameters we have:

ρ = 10

g=10

G=1

kv1=2

kv2=3;

K\_p=1

A1=10

u2=2;

A2=10

t\_step\_F=10

F\_0=0

F\_1=20

For tank level h1:

According to parameters value, we have static response:

When u1 change from 0 to 20, the h1 should be 1.

For tank level h2:

According to parameters value, we have static response:

When h1=1, h2 should equal to 0.111….., we can see from the scope that represent h2, the value is between 0.1 and 0.2