Laboratory 3

Helen Du

SID: 862081856

TA: Wang Hu

January 26, 2021

MODELING AND SIMULATION OF DYNAMIC SYSTEMS EE 105

SECTION 023

Objective:

The purpose of this lab is a familiarization with Simulink systems while exercising concepts such as transfer functions, time constants, pole locations, DC Gain, and frequency response.

Experimental Procedure:

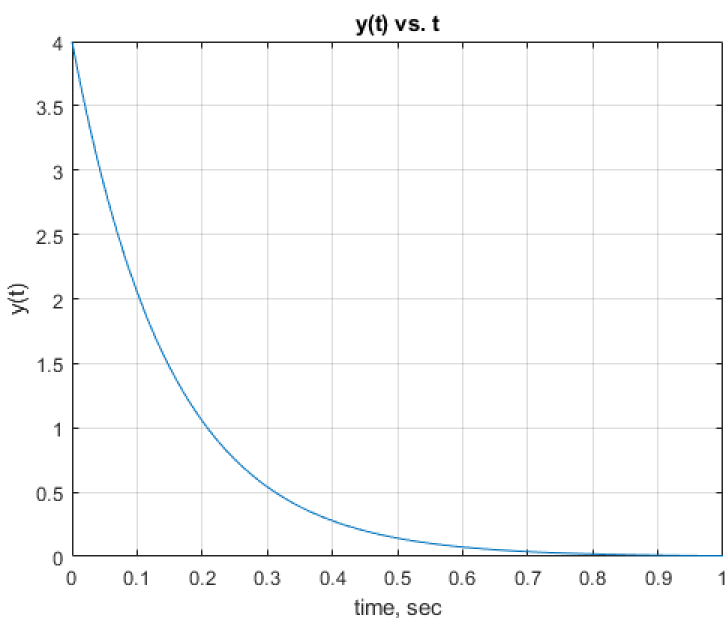
4.1 - Time Constant Estimation

1. Download from iLearn the data set listed for this lab. Plot y versus t. Make sure that the figure is properly labeled as indicated in Lab 1.

```
load('EE105_Lab3data.mat');
```

2. Section 1.3.1 describes two methods for estimation of time constants from data. Use each method to estimate the time constant for the data that you just plotted.
Use the `grid on' plot option. Note that you can zoom in on portions of the graph using the magnifying glass in the plot window menu. Ensure that your report clearly describes the method, computations, and data values that you use.

```
figure
plot(t, y)
ylabel('y(t)')
xlabel('time, sec')
title('y(t) vs. t')
grid on
```



Using method one:
$y(\tau) = 0.37y(0) = 0.37(4) = 1.48$

```
y_zero = 1.48;
[minimum, index] = min(abs(y-1.48));
tau = t(index)
```

```
tau = 0.1500
```

If we zoom in very closely in the graph, we can see that $y(0.1492) = 1.48$ meaning that $\tau = 0.1492 \text{ sec}$.

Using method two:

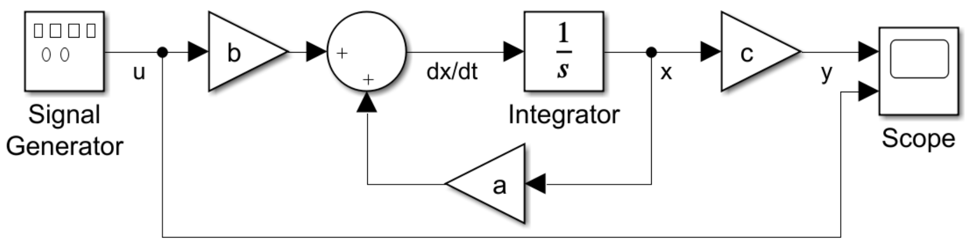
```
slope = (y(2) - y(1))/(t(2) - t(1));
% Using y = mx+b and setting y to 0 we know that tau = -b/m
b = 4;
tau = -b/slope
```

```
tau = 0.1551
```

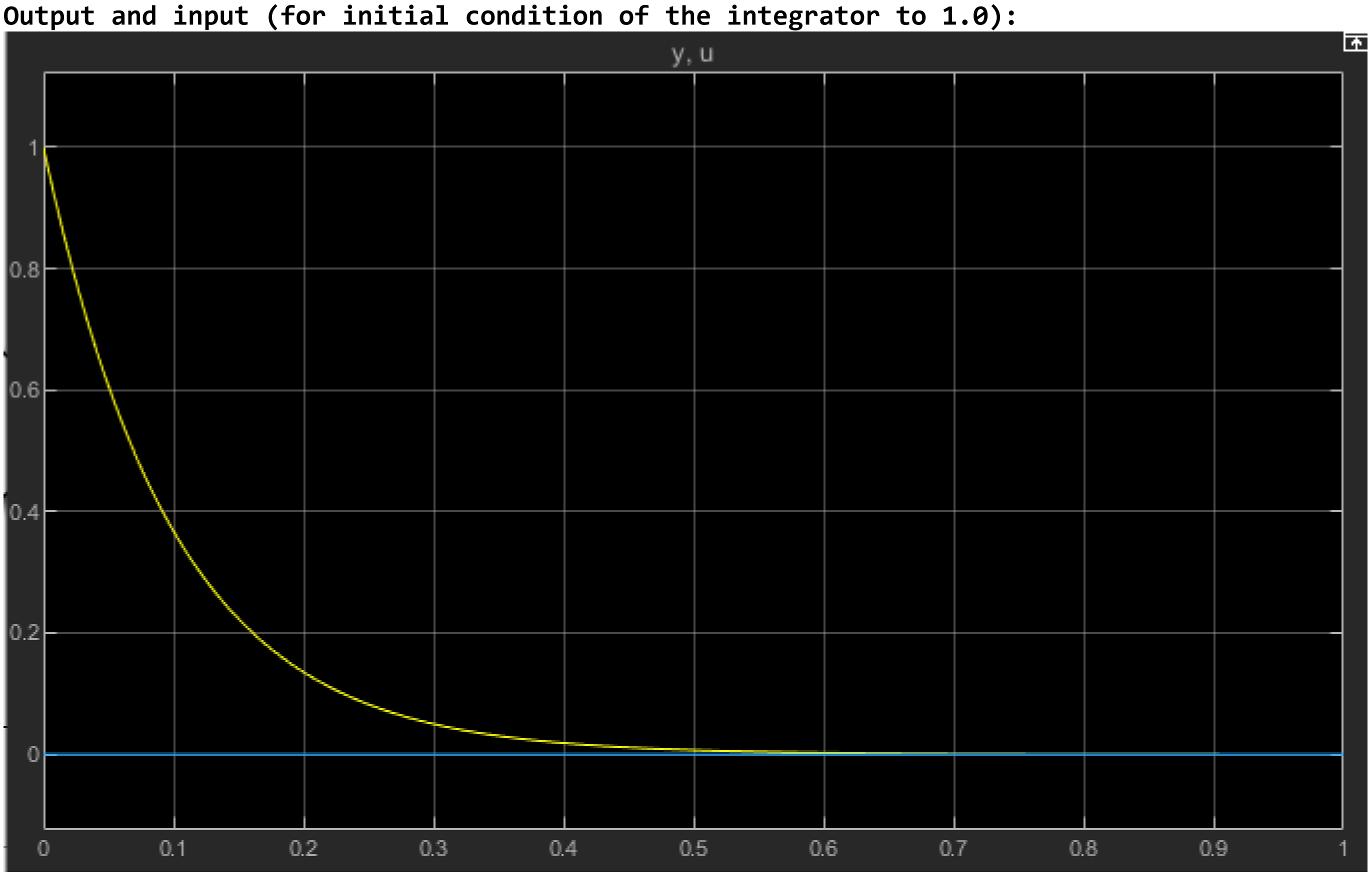
4.2 – Simulation

1. Simulation Setup

$$H(s) = \frac{1}{\mathrm{RCs}+1} = \frac{\frac{1}{\mathrm{RC}}}{s+\frac{1}{\mathrm{RC}}}, \text{where } a = -10, b = 10, \text{and } c = 1$$

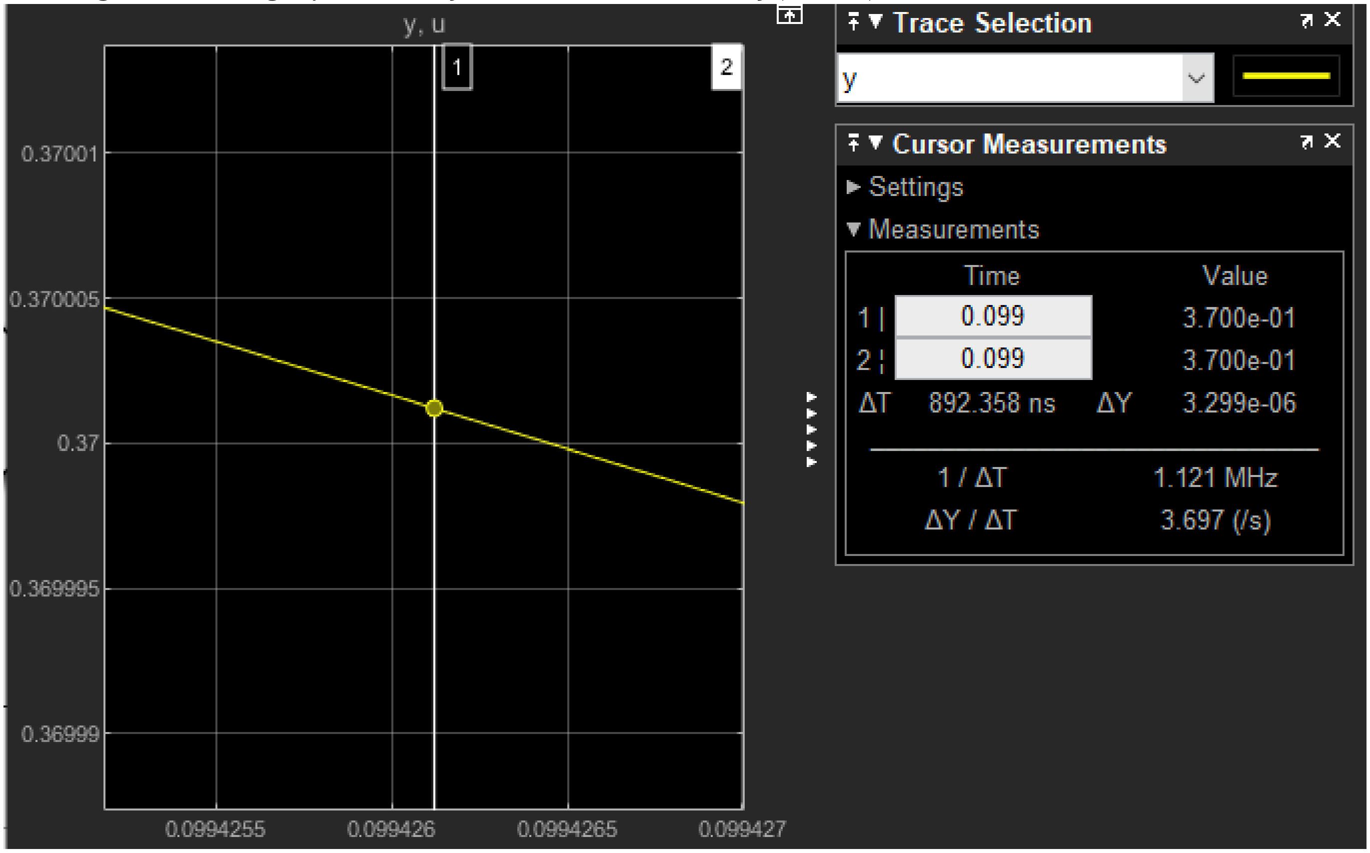


Output and input (for initial condition of the integrator to 1.0):

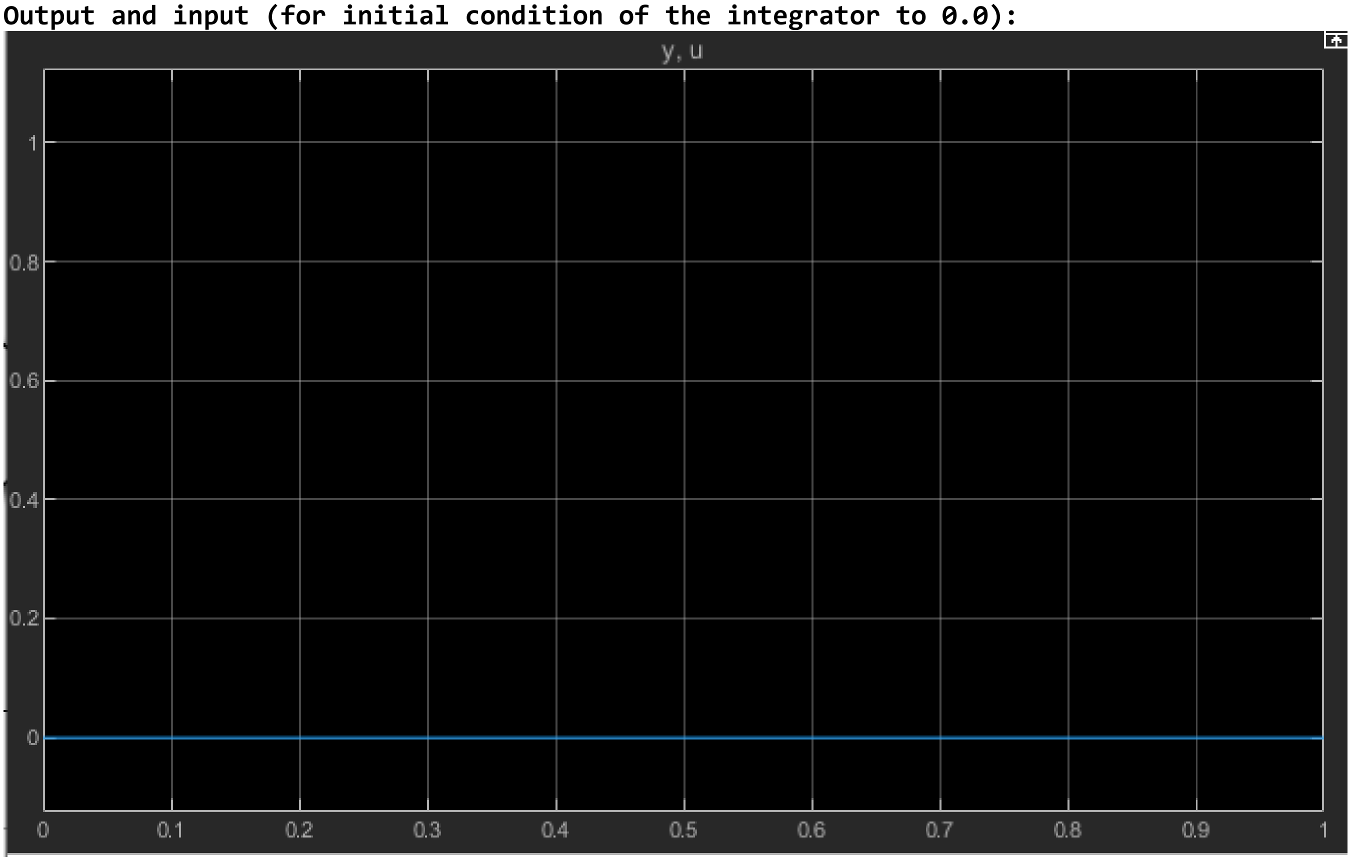


Blue - Input
Yellow - Output

Zooming into the graph where y = 0.37 shows that y(0.099) = 0.37, so $\tau = 0.099\,s \approx 0.01\,s$.



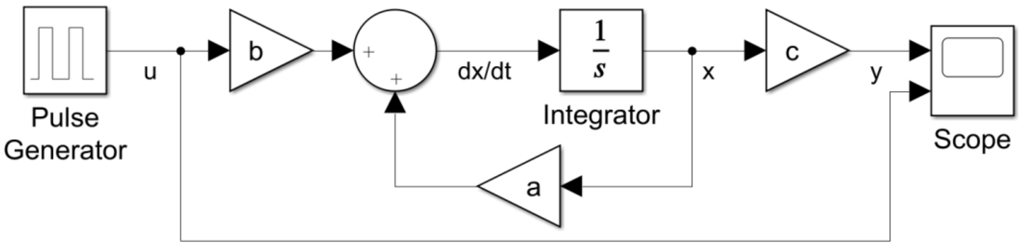
Output and input (for initial condition of the integrator to 0.0):



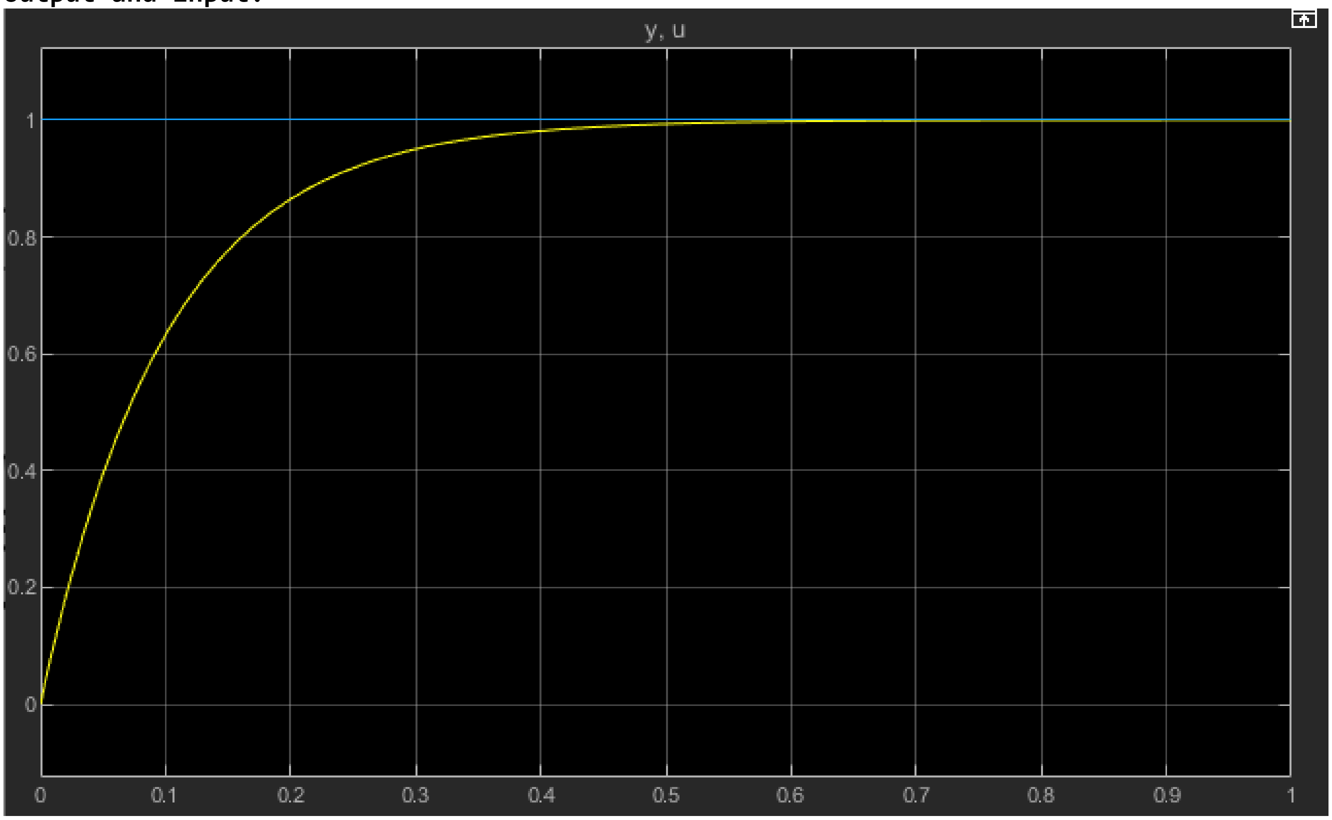
Blue – Input
Yellow – Output (Not visible)

2. Step Input

Model:

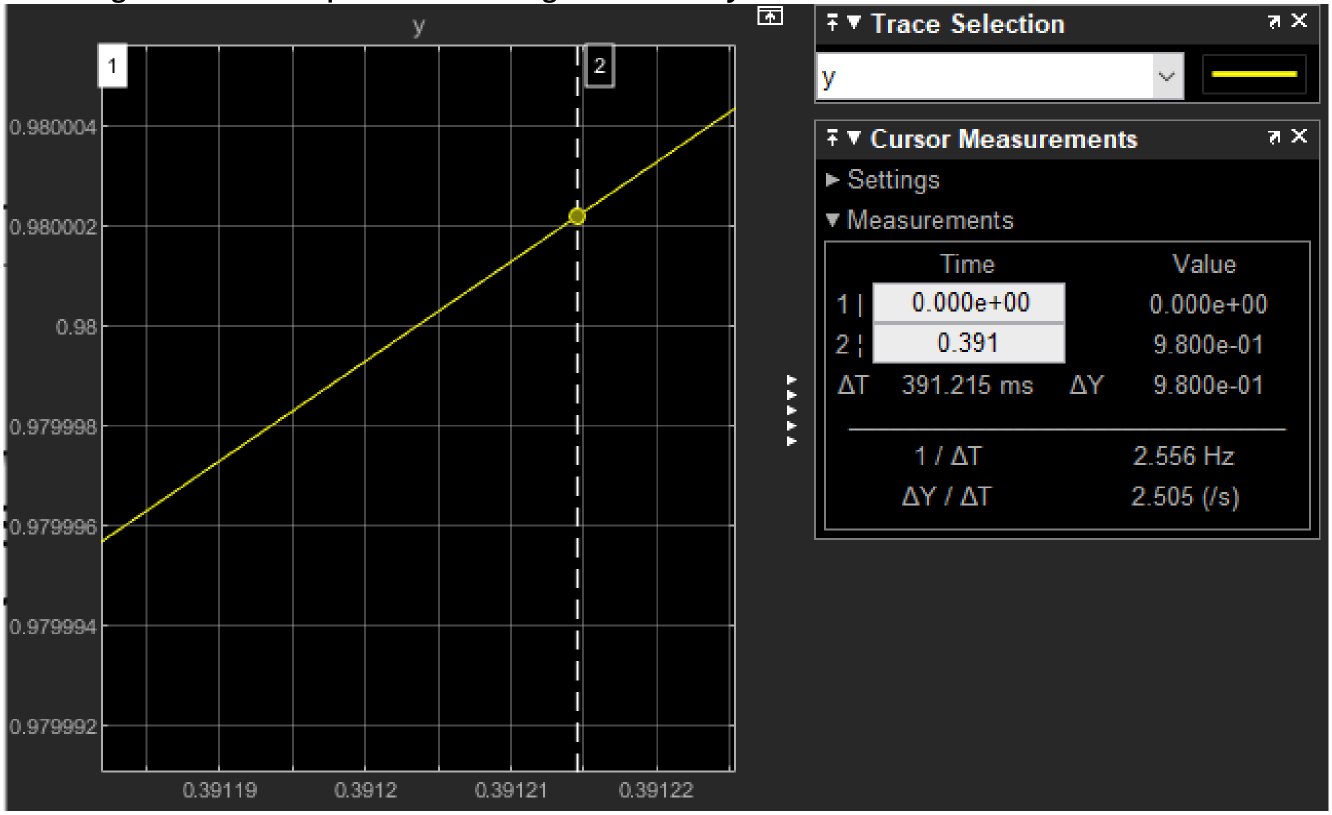


Output and input:



Blue – Unit Step Function (Input)
Yellow – Output

How long does the response take to get to steady state?



We know that for first-order linear systems, the system is considered to be steady state once it is within 2% of its final value. In the graph above, we can see that the response takes about 0.391 sec to reach steady state.

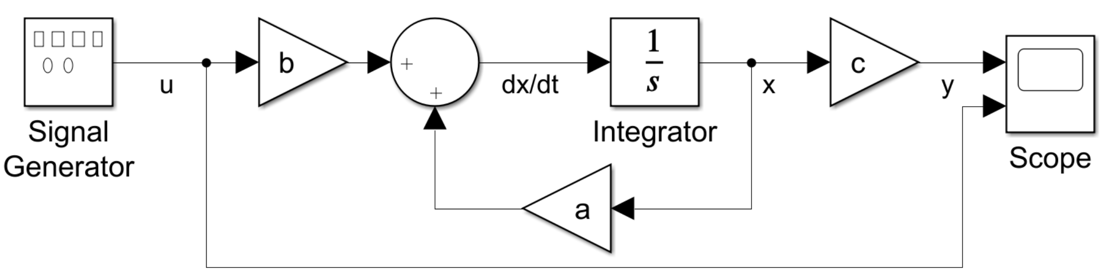
How does this compare with the time constant?
0.391 sec is roughly equal to 4 times the time constant $4\tau = 4 * 0.099 = 0.396\ \text{sec}$.

What is the steady state value of y? Does this match the value predicted by the DC Gain analysis?

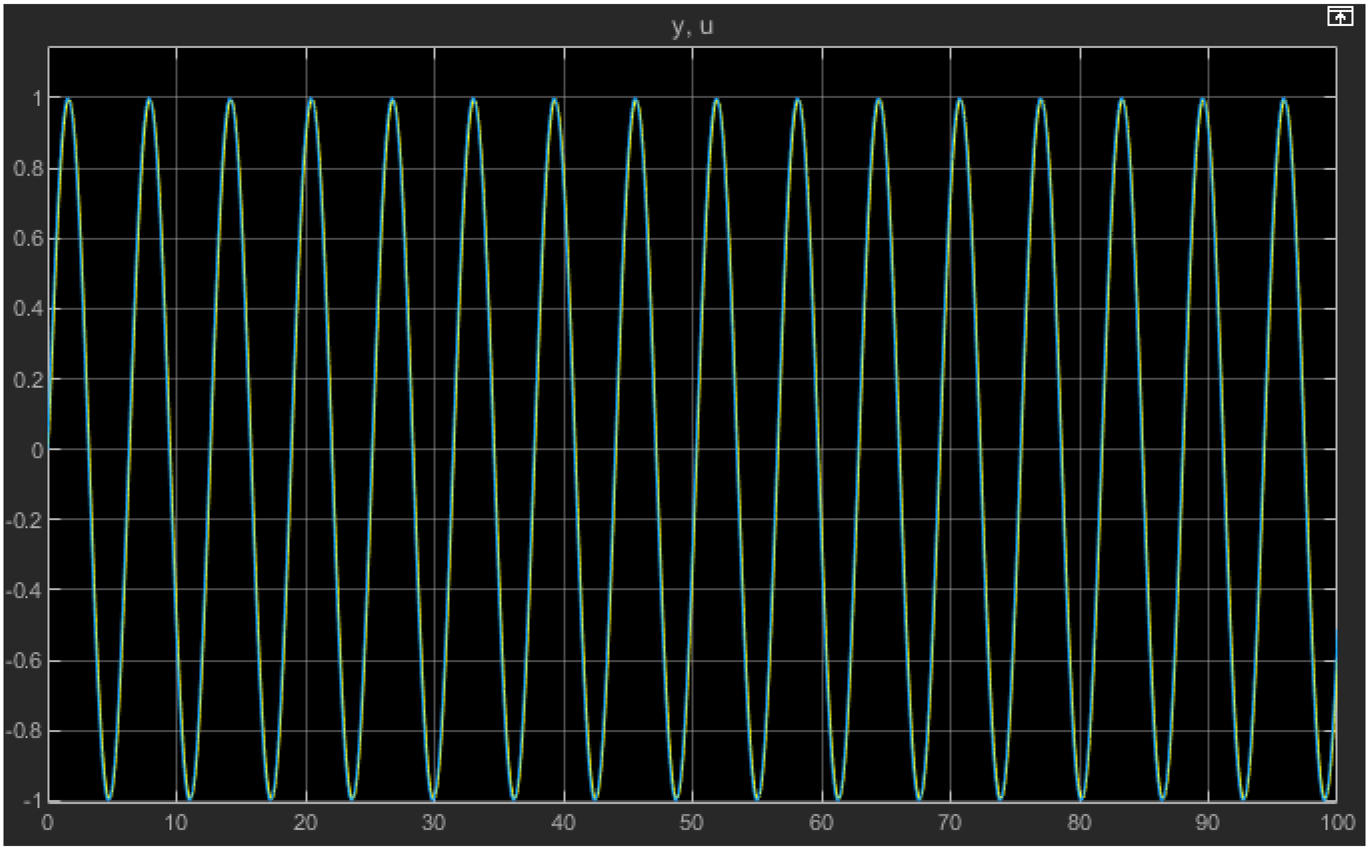
The steady state value of y is 1. For a first order, we know that $DC\ Gain = \frac{cb}{a} = \frac{1 * 10}{10} = 1$ which matches the value in the simulation.

3. Sinusoidal Input

Model:

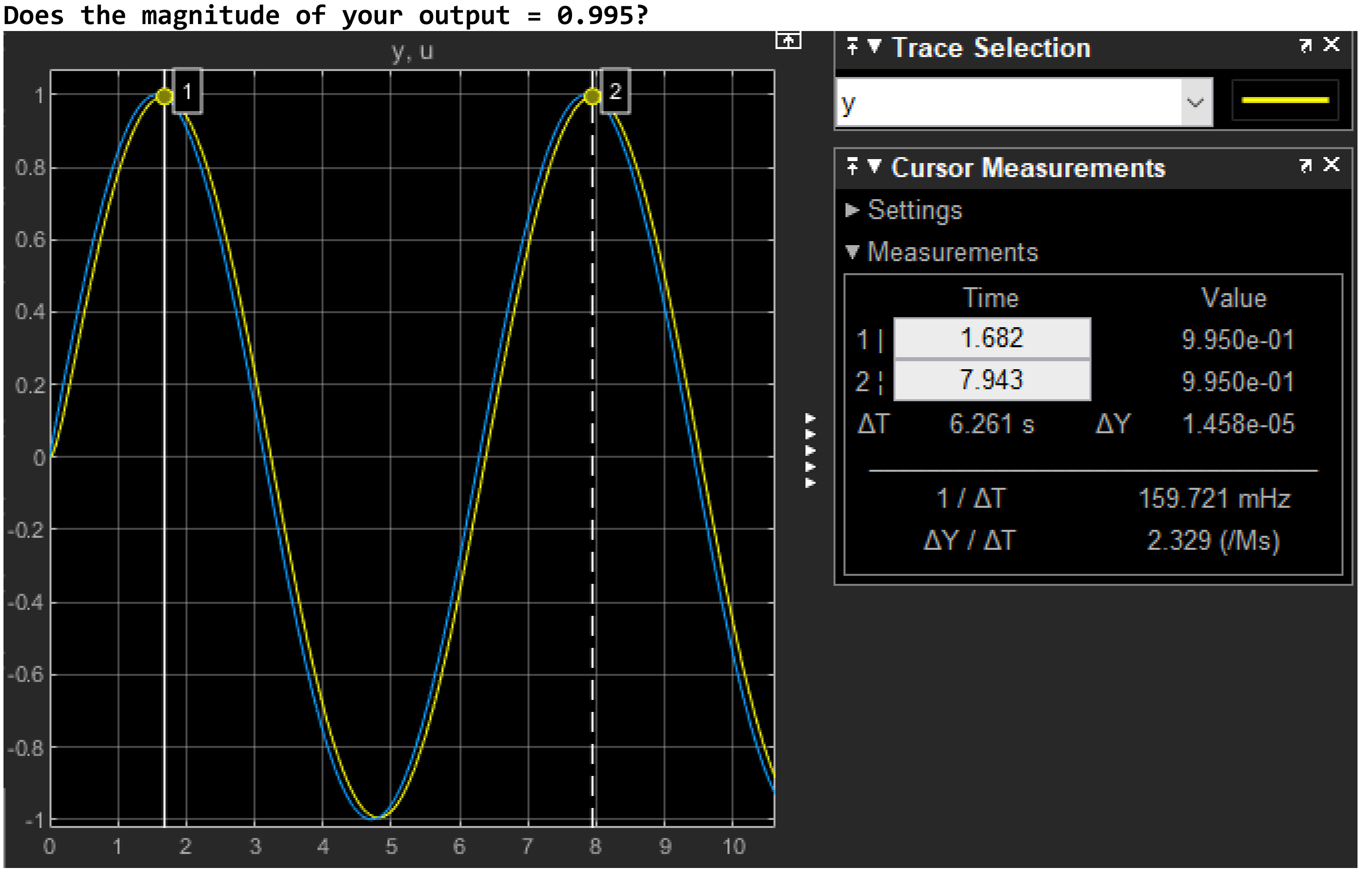


Output and input for $\omega = 1.00$:




```
Blue – sin(t) (Input)
Yellow - Output
```

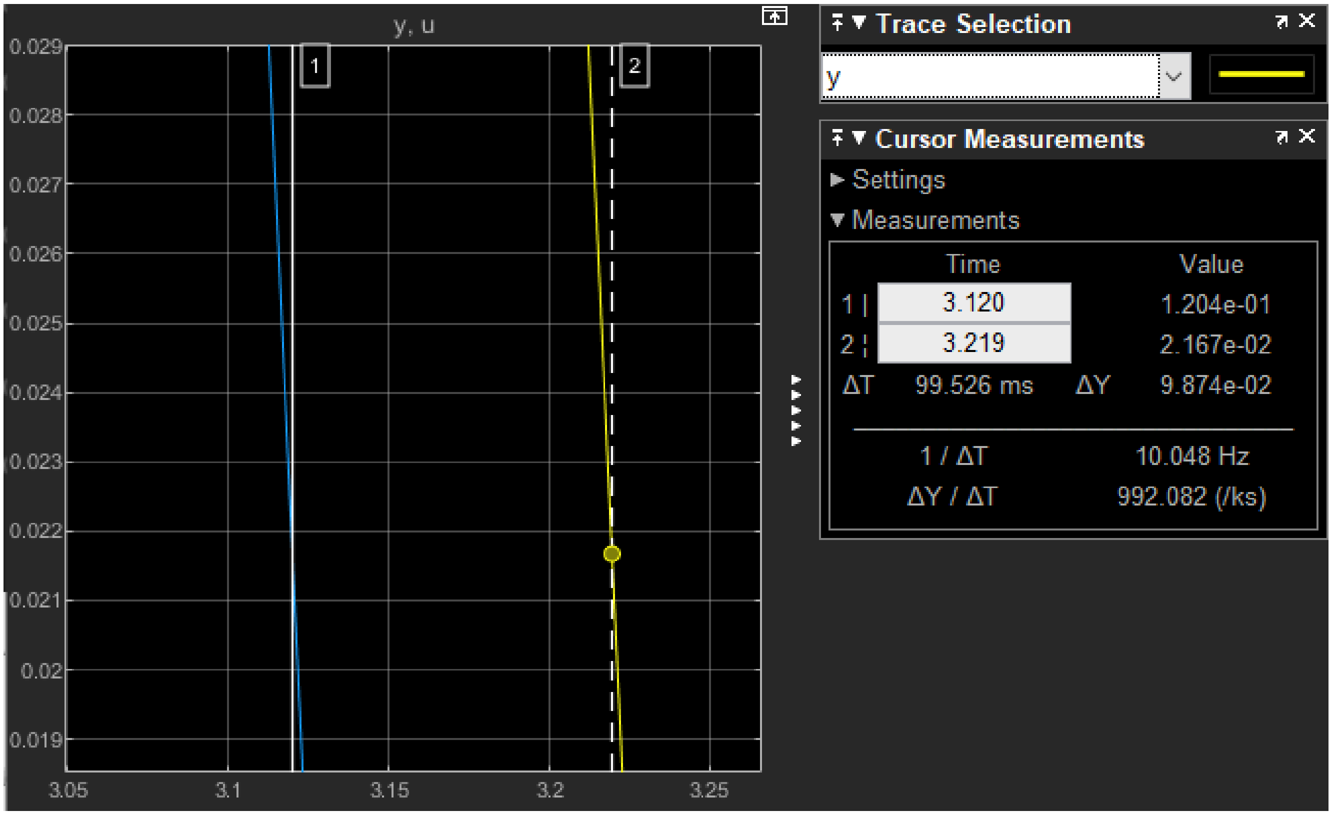
Does the magnitude of your output = 0.995?

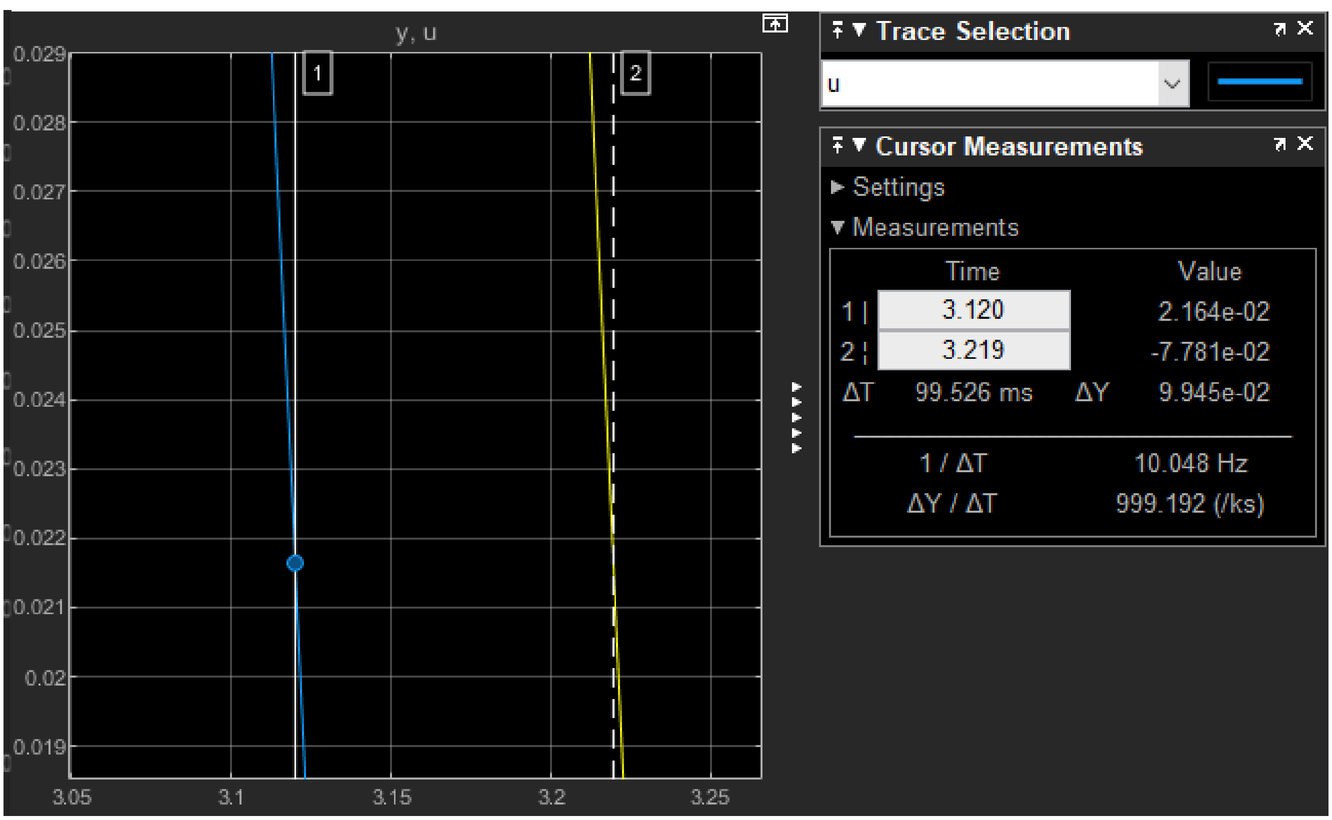


$$|H(j\omega)| = \frac{|Y(j\omega)|}{|U(j\omega)|} = \frac{|0.9950|}{|1|} = 0.9950$$

Yes, the magnitude of the output equals 0.995

Measure the phase between y and u in the simulation results. Show the 'cursor measurement'. Measure the phase shift. Note that the axis in the 'scope' is time 't'. You should convert the 'ΔT' to degree. Does the phase shift you measured approximately equal to -5.7106 degrees?





$\Delta t = 3.219s - 3.120s = 0.099s$

$\angle H(j\omega) = \dfrac{-\Delta t * 360^\circ}{2\pi/\omega} = \dfrac{-(0.099) * 360^\circ}{2\pi/1} = -5.672^\circ$ which approximately equals -5.7106°

Conclusion:

Overall, the objective of this lab was accomplished. We were able to successfully gain a familiarization with Simulink systems while exercise concepts such as transfer functions, time constants, pole locations, DC Gain, as well as frequency response.