Introduction to MATLAB / Simulink

The objective of this take home lab is to help you become familiar with the features of the MATLAB / Simulink computing environment that will be helpful to you in this course. In addition to answering the questions, please take some time to explore the software.

You may work together in groups to complete the lab, but you must hand in your own lab report. If you work with a group, please identify the people that you worked with on your report. **Computer printout may be included in your report as an appendix, but please do not provide these as your entire report.**

MATLAB /Simulink

2.5points 1. Given the following matrices:

$$\mathbf{A} = \begin{bmatrix} 15 & 10 & 5 \\ 6 & 3 & 6 \end{bmatrix}, \mathbf{B} = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}, \mathbf{c} = \begin{bmatrix} 7 & 5 & 3 \end{bmatrix}, \mathbf{D} = \begin{bmatrix} 6 & 0 \\ 0 & 7 \end{bmatrix}$$

Calculate each of the following:

(a) $\mathbf{AB}$

(b) $\mathbf{BA}$

(c) $\mathbf{A}^T\mathbf{c}$

(d) $\mathbf{cA}^T$

(e) $\mathbf{c}(\mathbf{B}+\mathbf{D})\mathbf{Ac}^T$

3points 2. Calculate the inverse, eigenvalues and eigenvectors for the following matrices using the "*inv*" and "*eig*" commands.

$$\mathbf{B} = \begin{bmatrix} 1 & 0 \\ -1 & -3 \end{bmatrix}, \mathbf{C} = \begin{bmatrix} 1 & 3 & 5 \\ 3 & 1 & 3 \\ 5 & 3 & 1 \end{bmatrix}$$

2points 3. Plot the following two functions on the same graph in increments of 0.1 for x:

$$\begin{cases} y_1(x) = x\ e^{-x} \\ y_2(x) = x\ e^{-x^2} \end{cases}, \quad x \in [0, 5]$$

4. Using the differential equation editor ("*dee*"), set up a Simulink simulation for the system:

6 points

$$\frac{dx_1}{dt} = -2x_1 + 5u$$
$$\frac{dx_2}{dt} = \frac{1}{2}x_1 - 3x_2$$
$$y_1 = x_1 + x_2$$
$$y_2 = x_1 - x_2$$

Plot the step, impulse, and sinusoidal response. Please plot all output variables on the same plot for each input type. Please include a legend on your plots.

5. Consider the following process transfer function:

4 points

$$G(s) = \frac{-s+1}{s^2+2s+1}$$

First use the MATLAB function "*zpk*" to import it into MATLAB. Then use the following MATLAB functions to calculate and plot each response of the transfer function.

(a) step

(b) impulse

(c) bode

(d) lsim (assume the input is a unit step signal)

6. Consider the following process transfer function:

5points

$$G(s) = \frac{2}{s^2+3s+1}e^{-3s}$$

First use the MATLAB function "*tf*" to import it into MATLAB. Then type "*ltiview*" at the MATLAB prompt to open an GUI window. Use this GUI to find the step response, settling time, rise time, final value and overshoot of the step response.

MATLAB/symbolic toolbox

1. Differentiate the following function with respect to x using the "*diff*" command:

2 points.

$$f(x) = x\, e^{-x^2}$$

Evaluate the derivative at $x = 0.5$ using the "*subs*" command.

2. Evaluate the following integrals using the "*int*" and "*evalf*" commands:

2.5 points

$$\text{a)} \quad I(x) = \int \frac{x}{1+x^2} dx$$

$$\text{b)} \quad I(x) = \int_0^{10} \frac{x}{1+x^2} dx$$

3. Calculate the gradient of the following function using the "*jacobian*" command:

2 points

$$f(x) = x_1 x_2 \, e^{x_2}$$

4. Calculate the Jacobian of the following set of equations using the "*jacobian*" command:

3 points

$$f(x) = \begin{bmatrix} 2x_1 + x_2 \\ x_1 x_2 \end{bmatrix}$$

Evaluate the Jacobian at $x = [1 \;\; 2]^T$.

5. Perform a fifth-order Taylor series expansion for the following function about the three points $x = 0, 1, 2$ using the "*taylor*" command:

3 points

$$f(x) = x \, e^{-x^2}$$

6. Solve the following differential equation with $u(t) = 1$ for $t \geq 0$ using the "*dsolve*" command.

5 points.

$$\frac{dx}{dt} = -x^2 + u, \qquad x(0) = 1$$

Plot your results.

$\cancel{x_1 \ln(x_2)}$ $\begin{bmatrix} \cancel{x_1 + x_2} \\ \cancel{x_1 - x_2} \end{bmatrix}$

TAKE HOME LAB-SOLUTIONS.
ChE 572 Lab#1
TOTAL MARKS: 40.

1. (a), (c), (e) → matrix dimensions not consistent.

(b) $BA = \begin{bmatrix} 36 & 23 & 16 \\ 27 & 16 & 17 \end{bmatrix}$

(d) $CA^T = \begin{bmatrix} 170 & 75 \end{bmatrix}$.

2.

$B^{-1} = \begin{bmatrix} 1 & 0 \\ -1/3 & -1/3 \end{bmatrix}$.

eig (B) = −3, 1.

eig. vector (corresponding to eig. value −3) = $\begin{bmatrix} 0 \\ -1 \end{bmatrix}$

eig. vector (corresponding to eig. value 1) = $\begin{bmatrix} 0.9701 \\ -0.2425 \end{bmatrix}$.

$C^{-1} = \begin{bmatrix} -0.1667 & 0.250 & 0.0833 \\ 0.250 & -0.50 & 0.250 \\ 0.083 & 0.250 & -0.1667 \end{bmatrix}$.

eig(C) = −4; −1.4244; 8.4244.

eig. vector (corresponding to eig. value −4) = $\begin{bmatrix} -0.7071 \\ 0.000 \\ 0.7071 \end{bmatrix}$

eig. vector (corresponding to eig. value −1.4244) = $\begin{bmatrix} 0.3508 \\ -0.8682 \\ 0.3508 \end{bmatrix}$

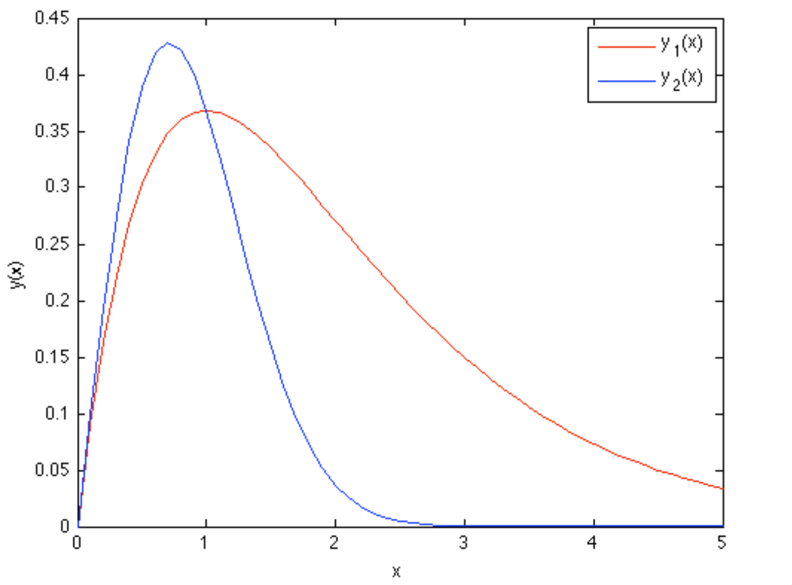
eig. vector (corresponding to eig. value 8.4244) = $\begin{bmatrix} 0.6139 \\ 0.4961 \\ 0.6139 \end{bmatrix}$

3. See the attached graph.
4. See the attached graph.
5. See the attached graph.

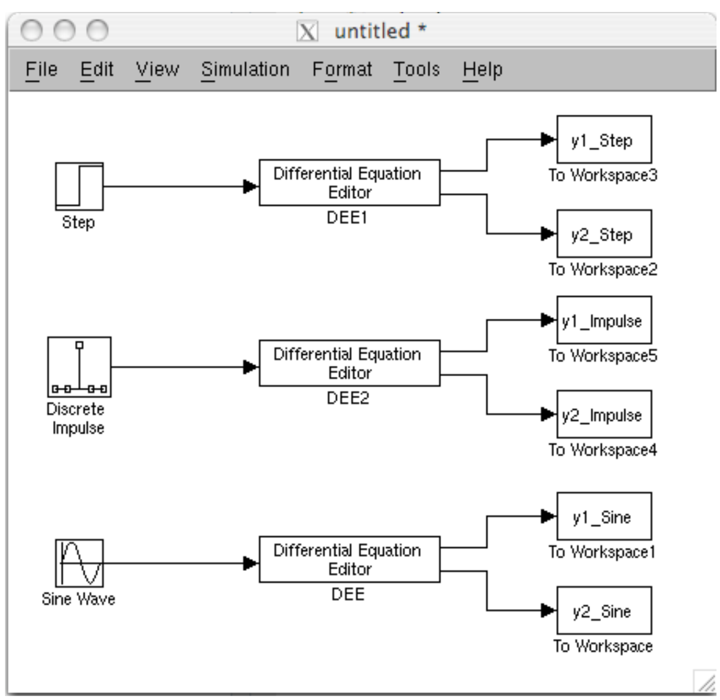
3) **MATLAB Command:**

```
x=0:0.1:5;
y1=x.*exp(-x);
y2=x.*exp(-x.^2);
plot(x,y1,'r')
hold on;
plot(x,y2,'b')
```

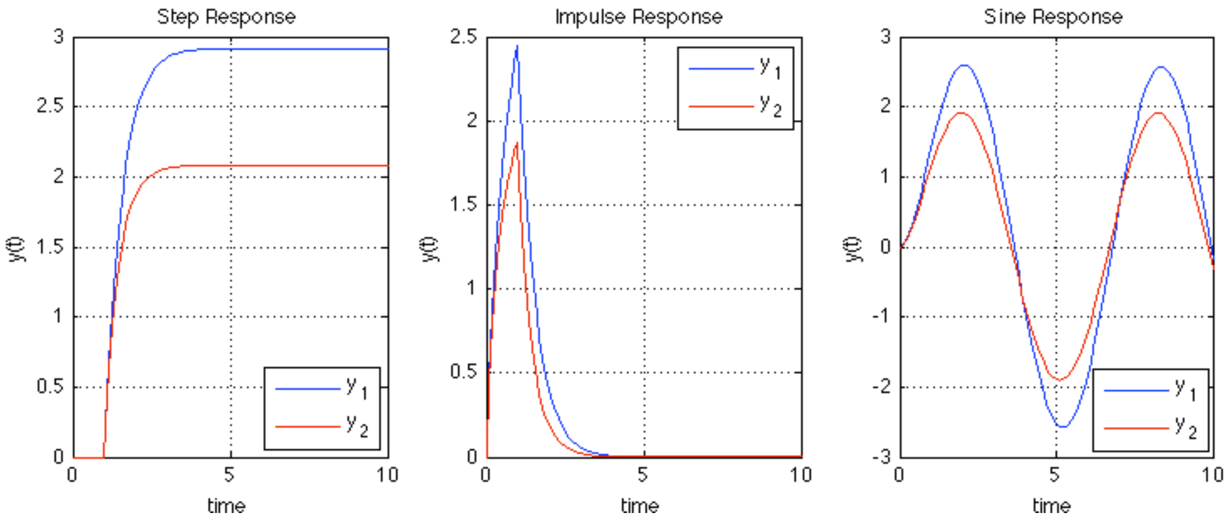
Solution:



4) **Simulink sheet:**



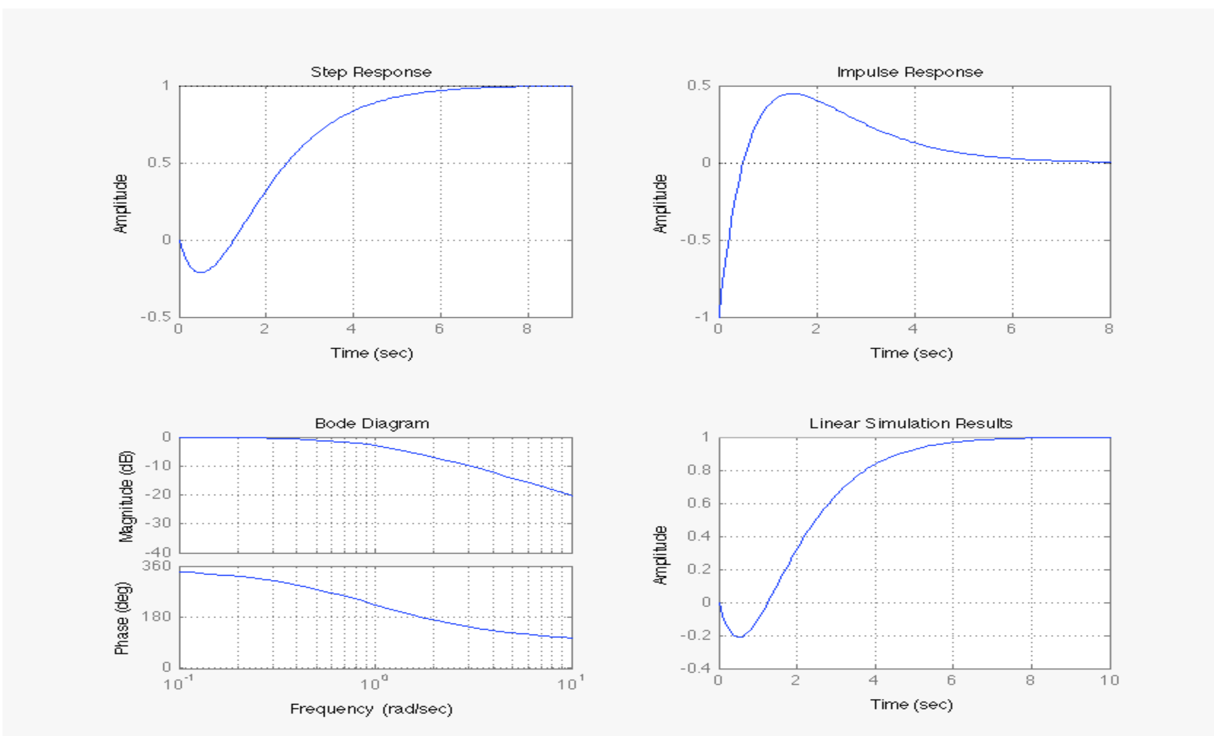
Solution



5) **MATLAB Command:**

```
G=zpk([1],[-1 -1],[-1]);
subplot(2,2,1);step(G);
subplot(2,2,2);impulse(G);
subplot(2,2,3);bode(G);
t=0:0.1:10;
u=ones(1,length(t));
subplot(2,2,4);lsim(G,u,t)
```

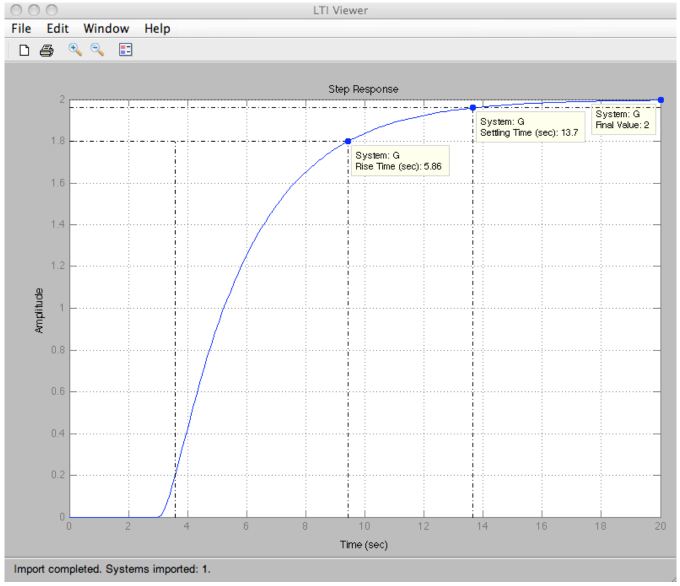
Solution:



6) **MATLAB Command:**

```
G=tf([2],[1 3 1],'InputDelay',3)
```

Solution:



Settling time: 13.7 seconds
Rise Time: 5.86 seconds (time taken for the response to reach from 10% to 90% of the ultimate value)
Final Value: 2
Overshoot: 0

Note: In some textbooks, the rise time is defined as: the time required for the response to first reach its ultimate value.

MATLAB/symbolic toolbox

1-5) See the attached supporting Mupad file

6) **MATLAB Command**
x=dsolve('Dx=-x^2+1','x(0)=1')

Solution
x(t)=1