

The Islamic University - Gaza
Faculty of Engineering
Department of Computer Engineering



Linear Control Lab
“HW 1”

Student Name:
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Student ID: 120221230

Supervisor:
Eng. Nael Dokhan

Question 1:

- a. Generate a matrix of size 4×4 of normally distributed random numbers.

```
>> A = rand(4)
```

```
A =
```

0.9157	0.0357	0.7577	0.1712
0.7922	0.8491	0.7431	0.7060
0.9595	0.9340	0.3922	0.0318
0.6557	0.6787	0.6555	0.2769

- b. Change the value of the 3rd column to [6 9 2 5].

```
>> A(:,3) = [6 9 2 5]
```

```
A =
```

0.9157	0.0357	6.0000	0.1712
0.7922	0.8491	9.0000	0.7060
0.9595	0.9340	2.0000	0.0318
0.6557	0.6787	5.0000	0.2769

- c. Delete the 2nd row.

```
>> A(2,:) = []
```

```
A =
```

0.9157	0.0357	6.0000	0.1712
0.9595	0.9340	2.0000	0.0318
0.6557	0.6787	5.0000	0.2769

Question 2:

Consider the polynomial $p(x) = x^4 - 5x^3 + 7x - 10$

1. Find the roots of this polynomial.

```
>> coefficients = [1 -5 0 7 -10]

coefficients =

      1      -5       0       7     -10

>> roots(coefficients)

ans =

    4.7856 + 0.0000i
   -1.4631 + 0.0000i
    0.8387 + 0.8513i
    0.8387 - 0.8513i
```

2. From these roots, reconstruct $p(x)$.

```
>> poly(ans)

ans =

    1.0000   -5.0000         0     7.0000  -10.0000
```

3. Find the value of $p(x)$ at $x=2$.

```
>> polyval(coefficients,2)

ans =

   -20
```

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Linear Control Lab
“HW 2”

Student Name:
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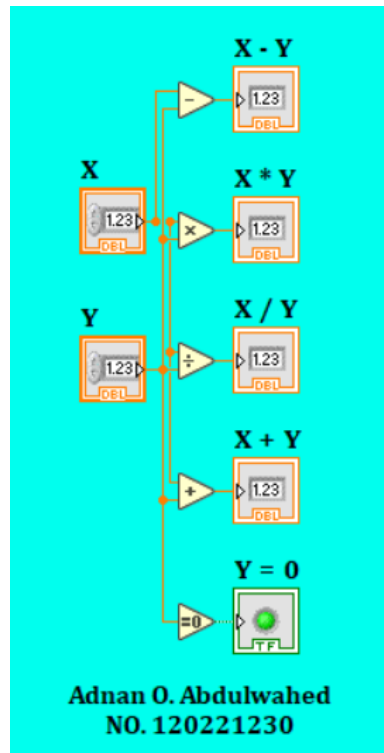
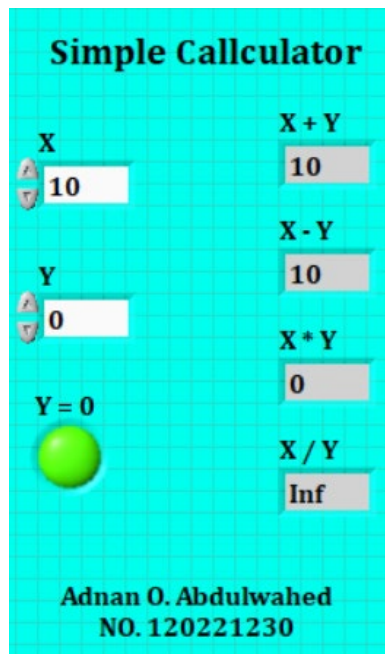
Supervisor:
Eng. Nael Dokhan

Question 1: Three Examples in Lab:

A.

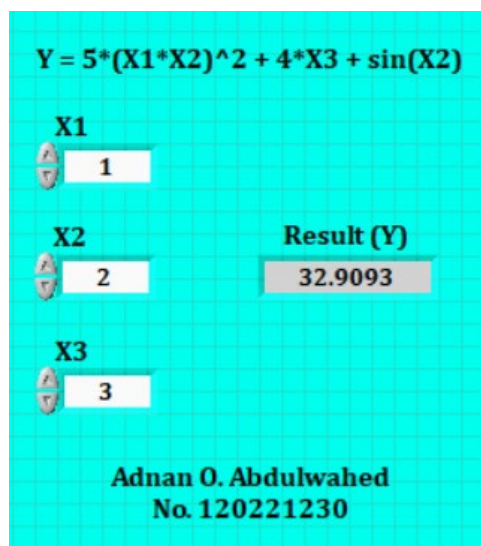
Block Diagram

Front Panel

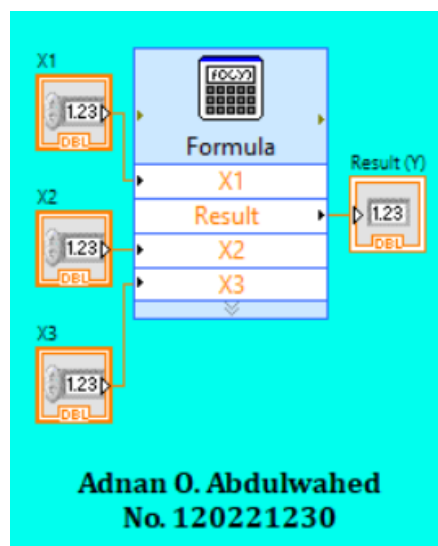


B.

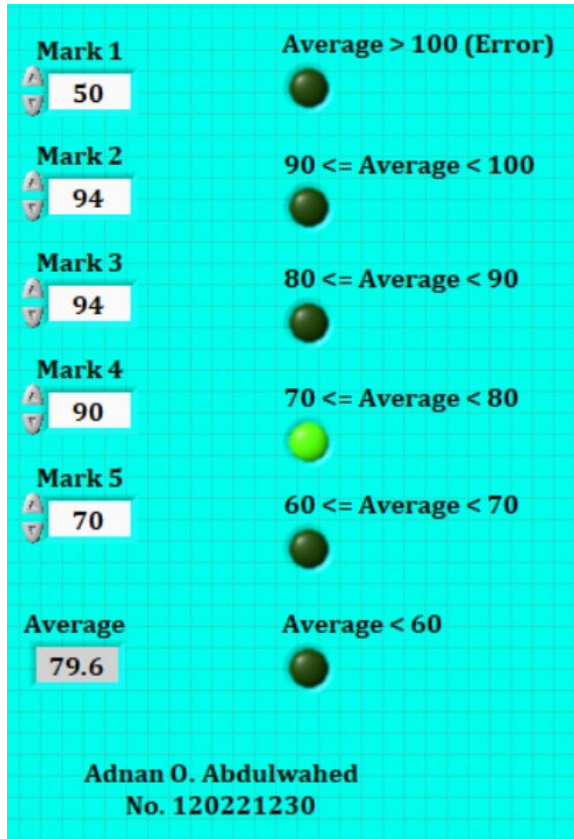
Front Panel



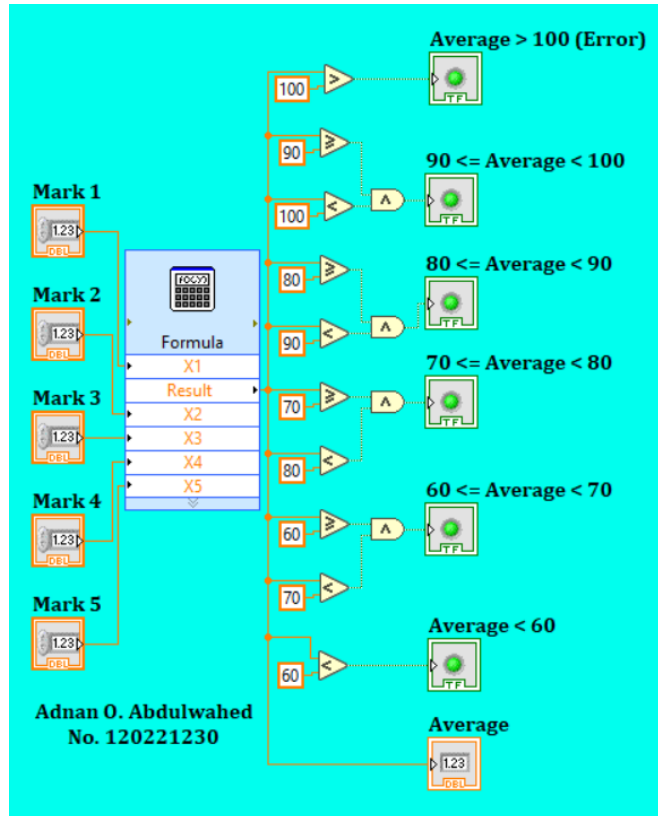
Block Diagram



C. Front Panel

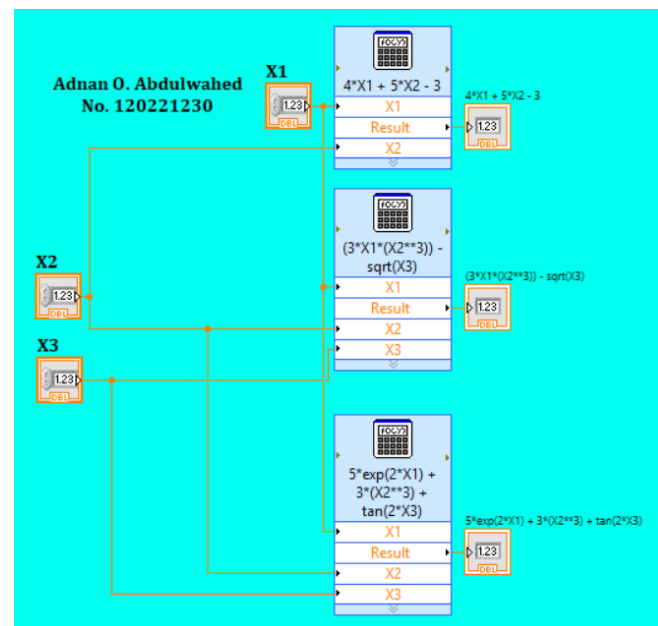
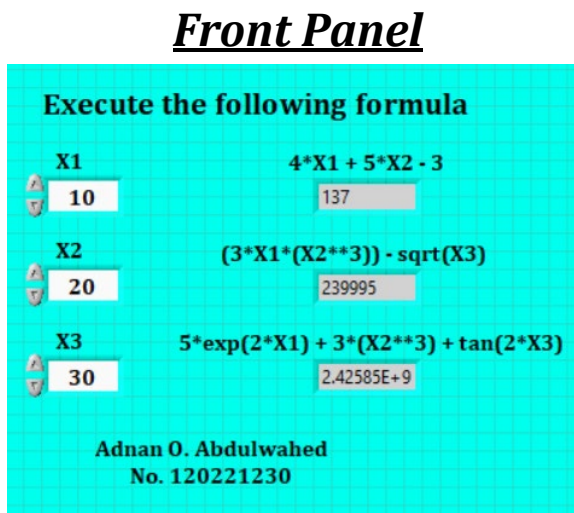


Block Diagram



Question 2: Make a LabVIEW program that execute the following formula:

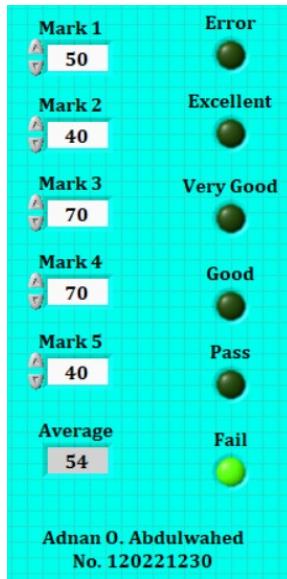
Block Diagram



Question 3:

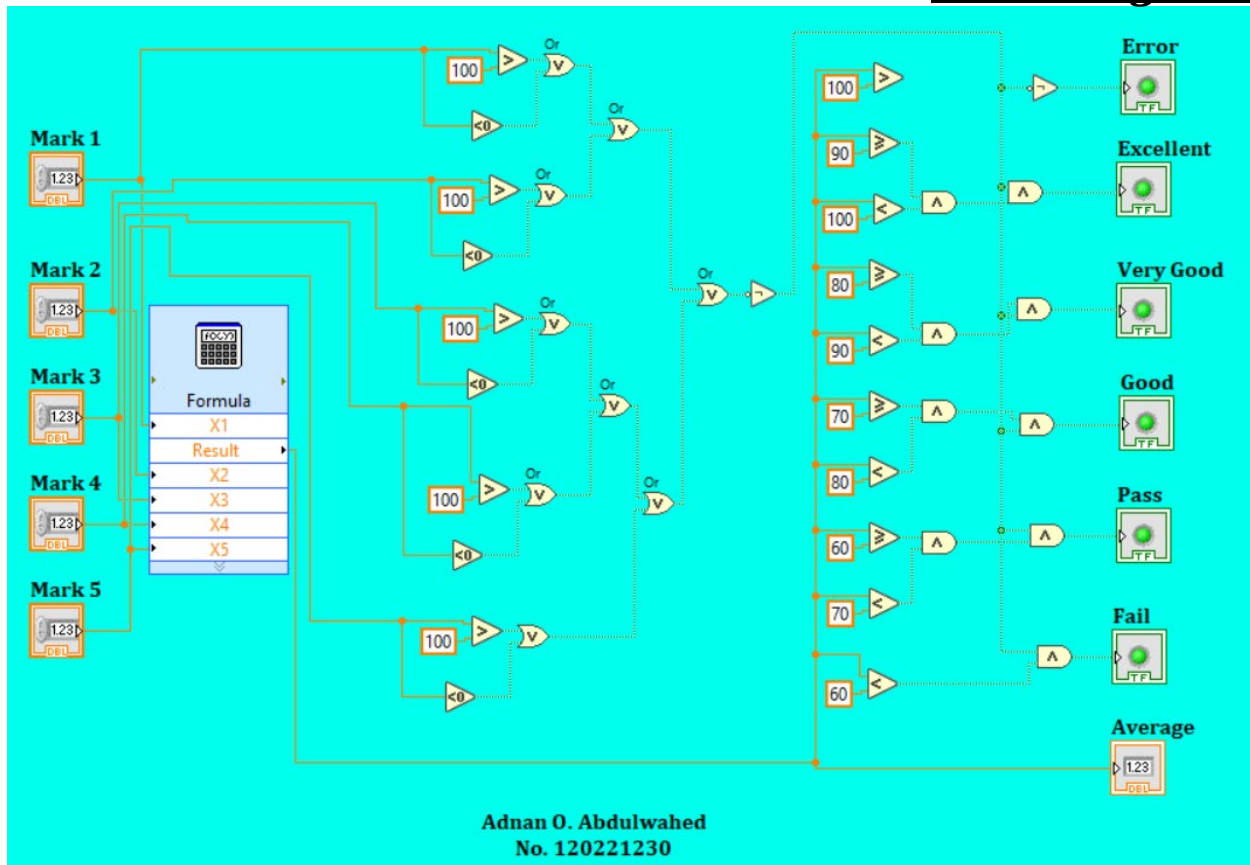
Solution 1:

Front Panel



By using Logic Gates only:

Block Diagram



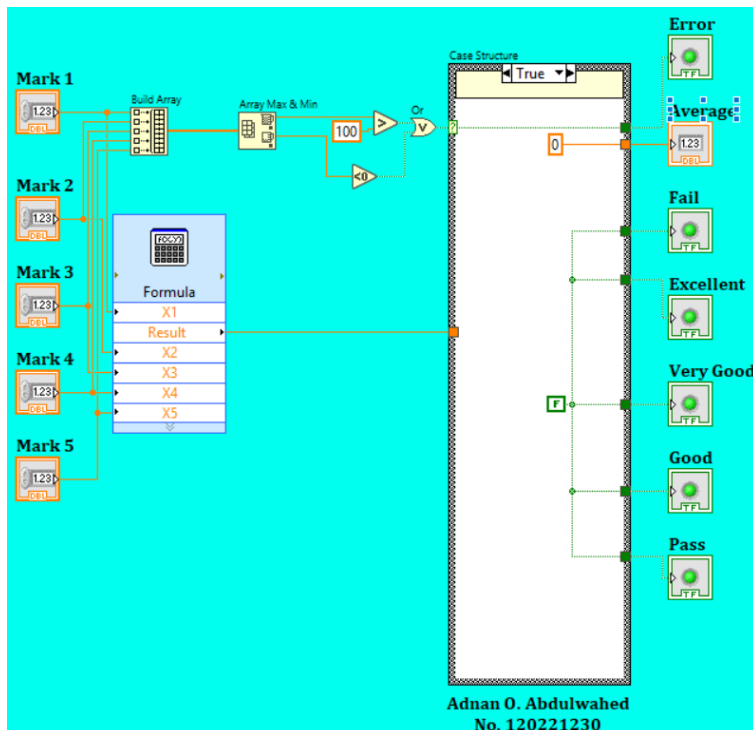
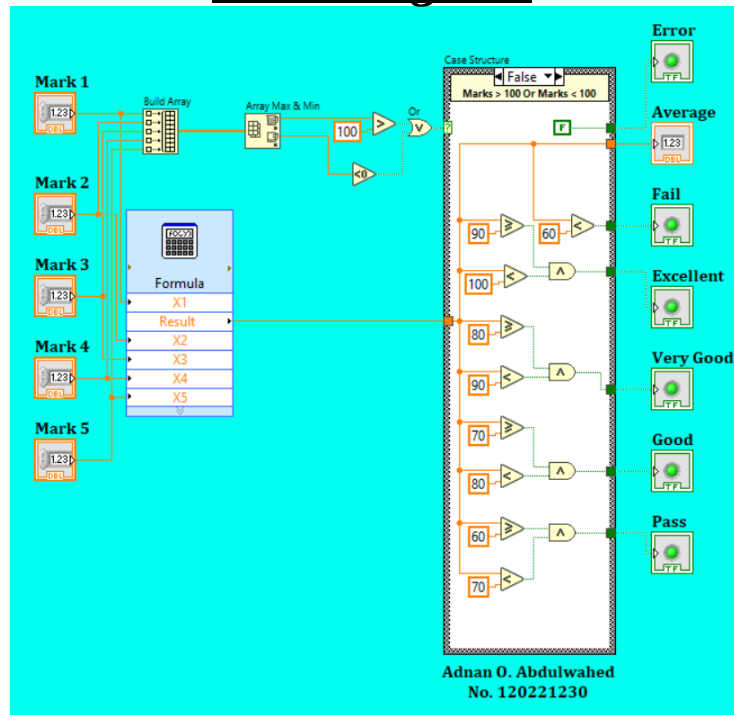
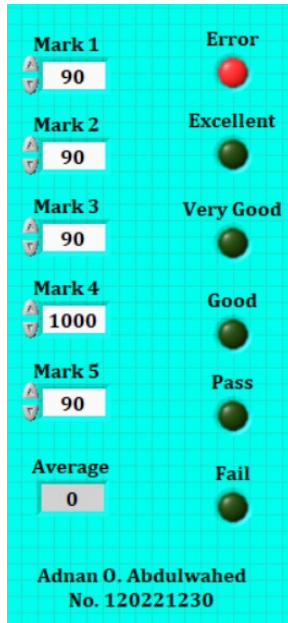
Solution 2:

By using the Case Structure, similar to an if statement.

The advantage of this solution is that the average becomes zero when an error occurs.

Block Diagram

Front Panel



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Linear Control Lab
“HW 3”

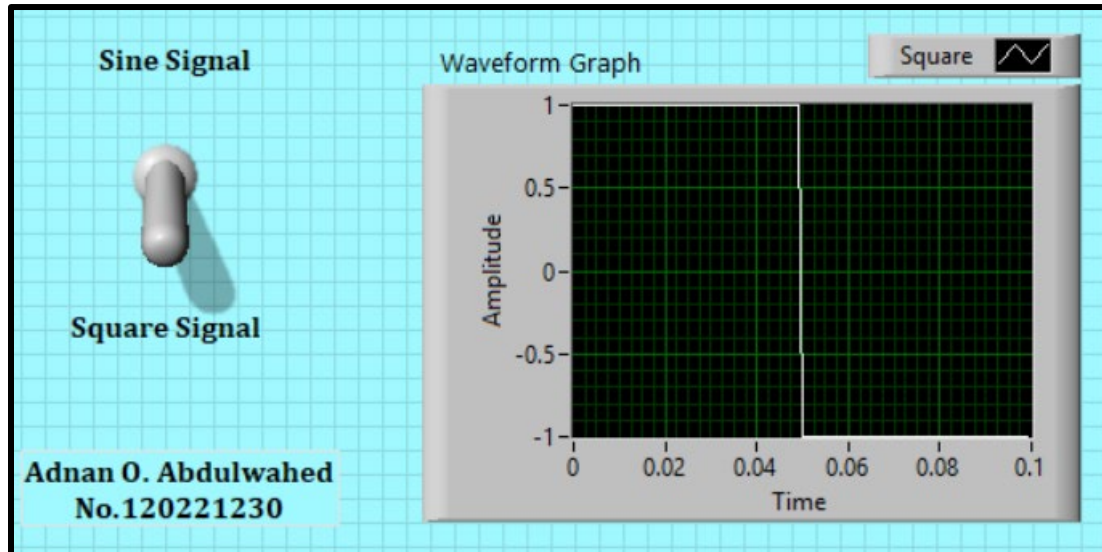
Student Name:
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Student ID: 120221230

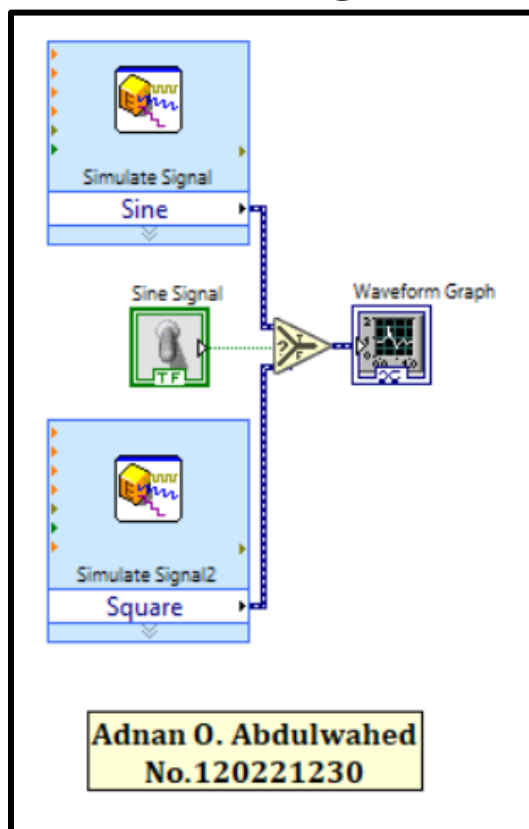
Supervisor:
Eng. Nael Dokhan

Question 1: Two Examples in Lab:

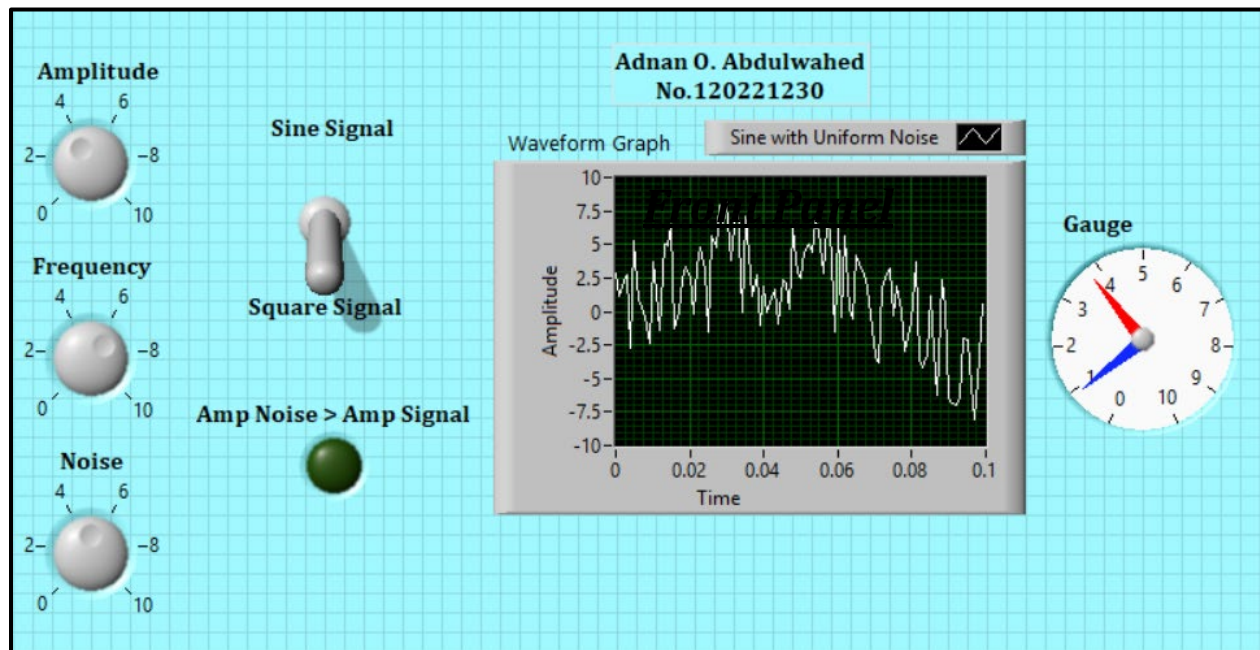
A. Front Panel



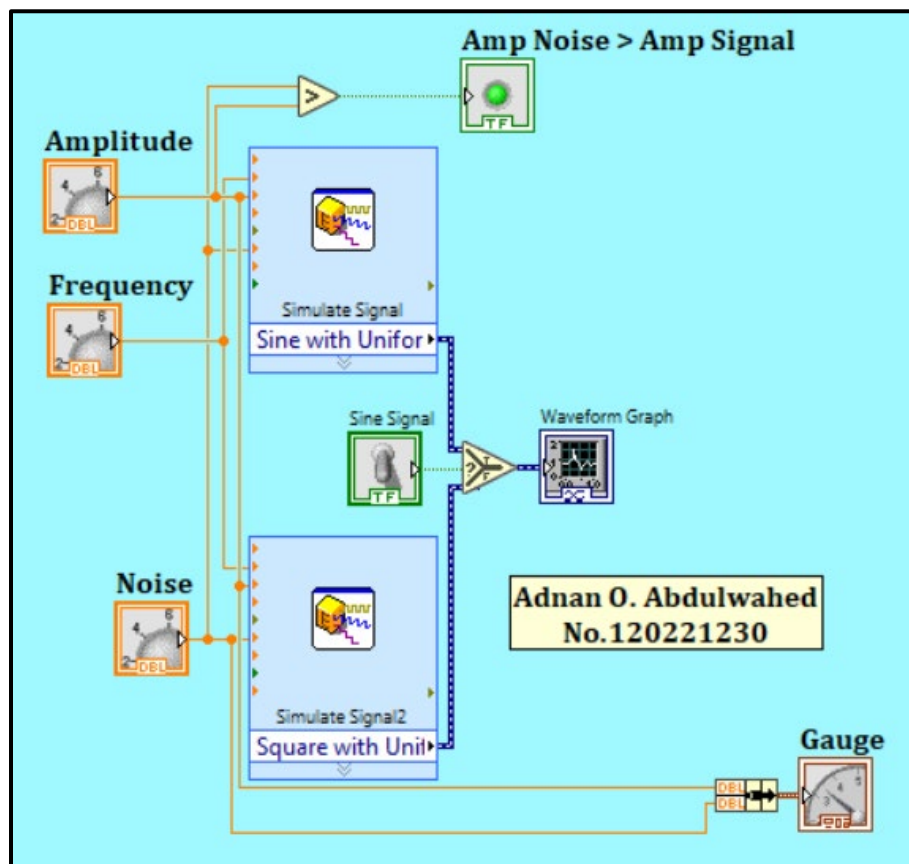
Block Diagram



B. Front Panel

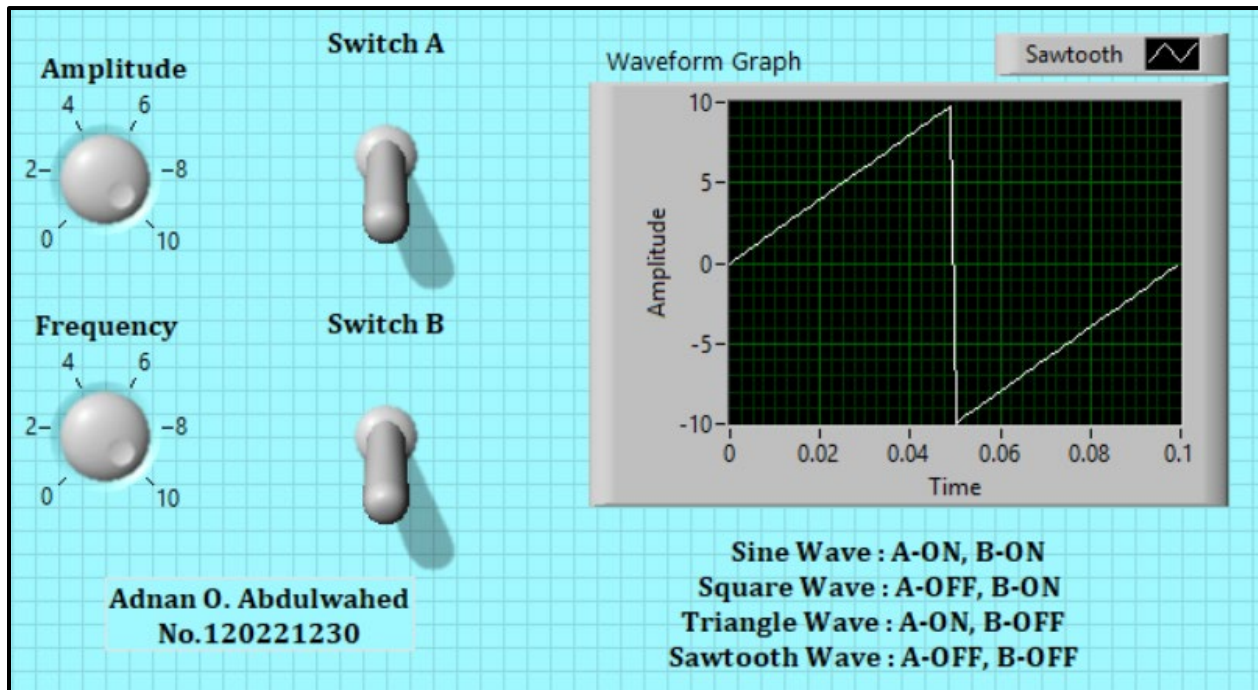


Block Diagram

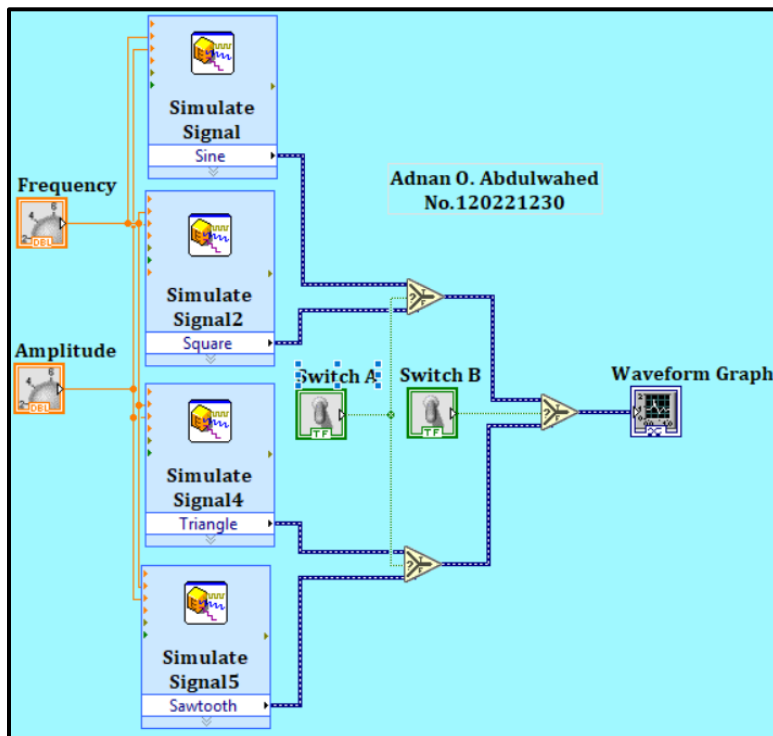


Question 2:

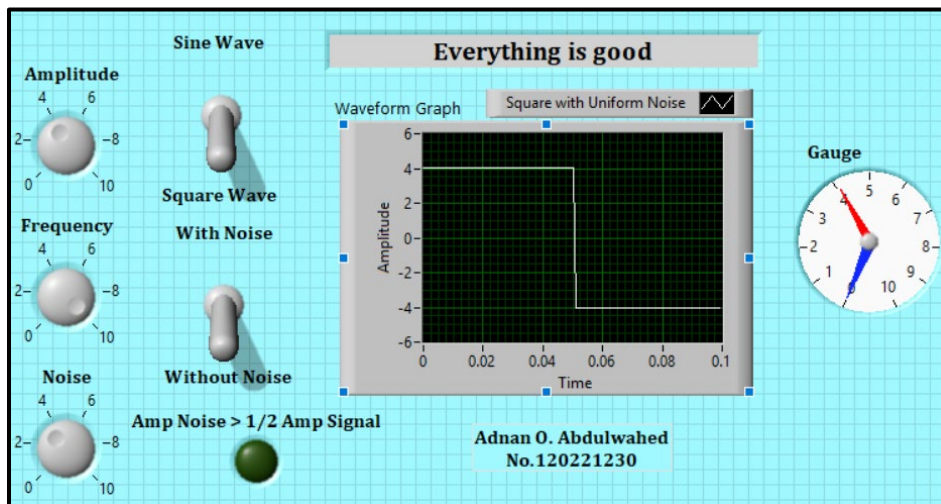
A. Front Panel



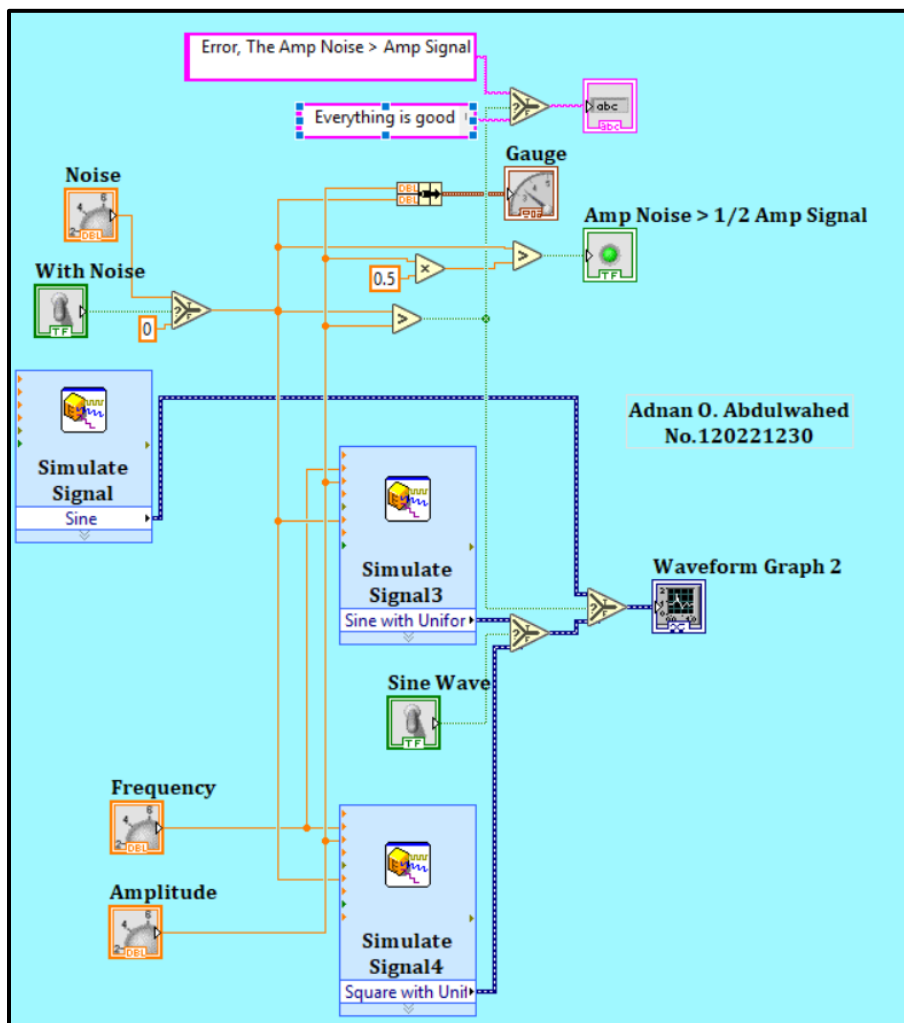
Block Diagram



B. Front Panel



Block Diagram



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Linear Control Lab
“HW 4”

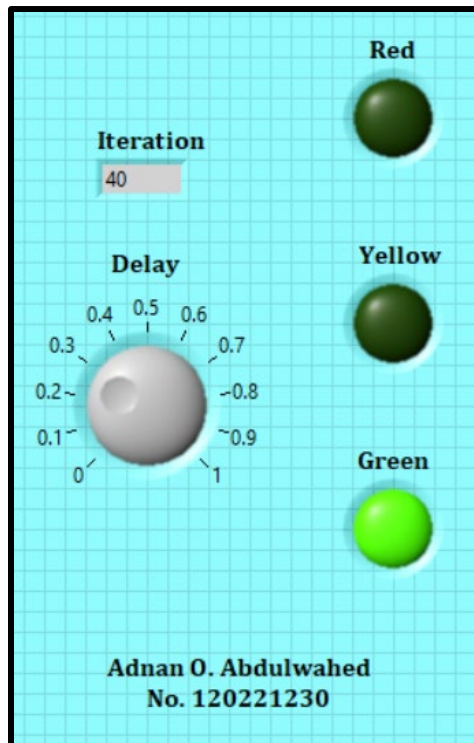
Student Name:
Adnan Osama Abdulwahed

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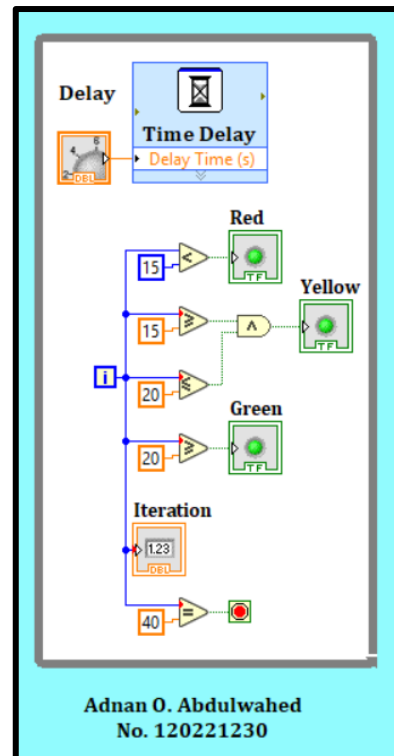
Supervisor:
Eng. Nael Dokhan

Question 1: Two Examples in Lab:

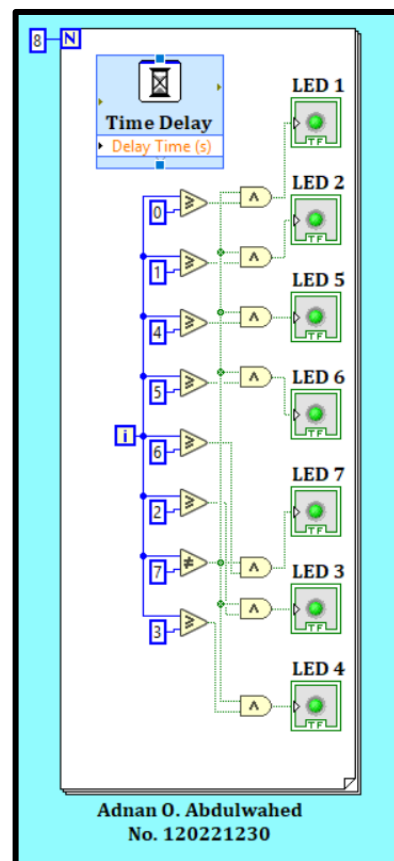
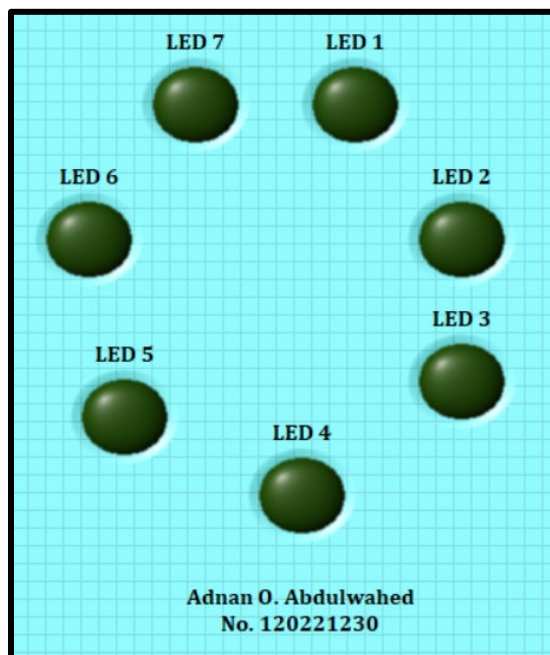
A. Front Panel



Block Diagram



B. Front Panel



Question 2: Lab work:

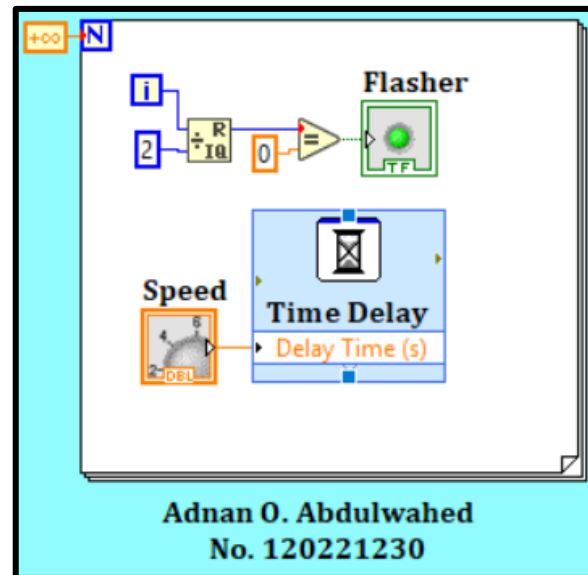
A.

By For Loop:

Front Panel

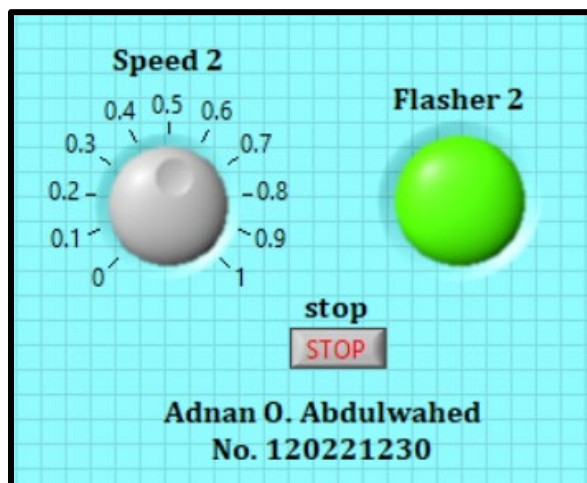


Block Diagram

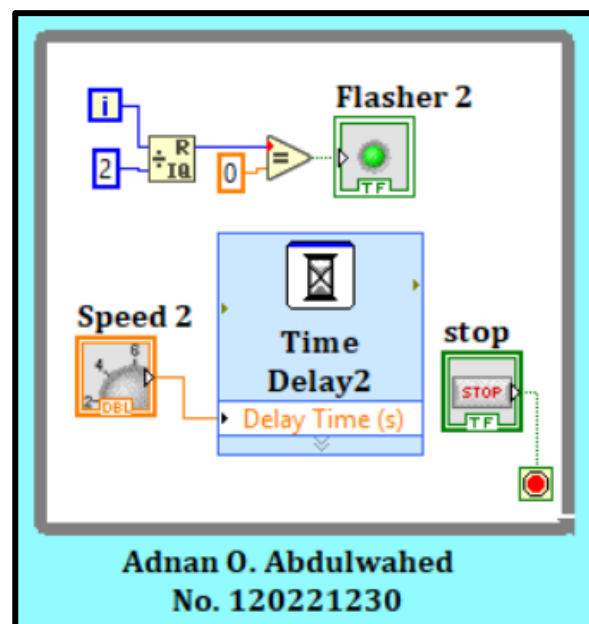


By While Loop:

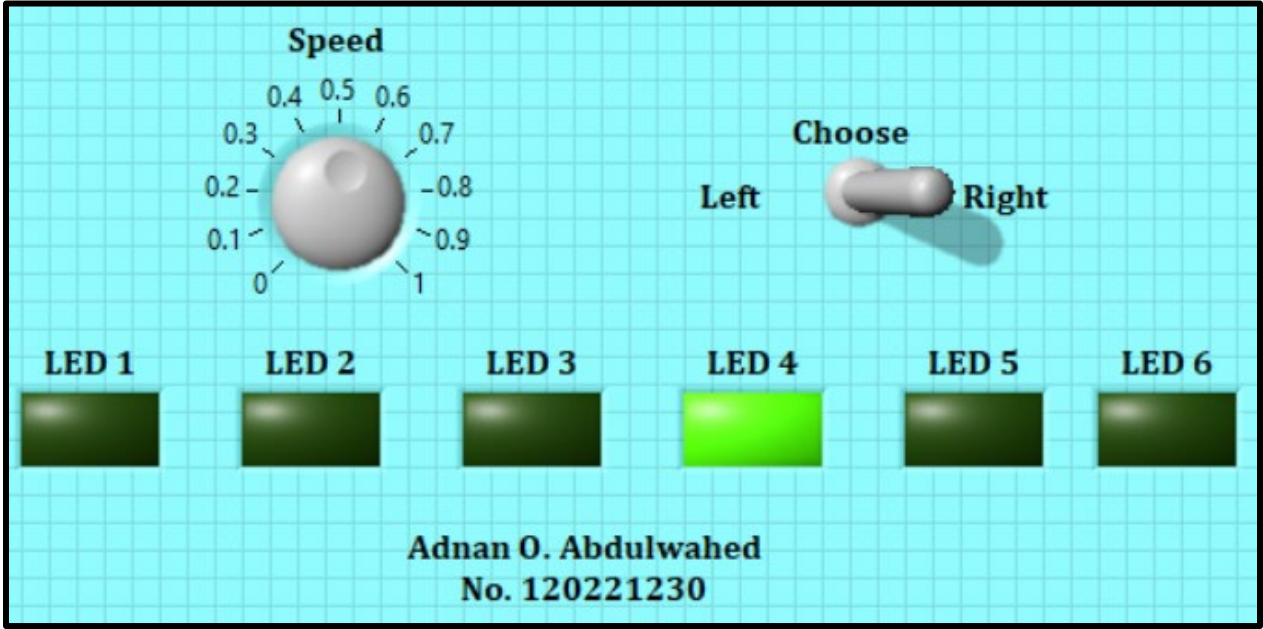
Front Panel



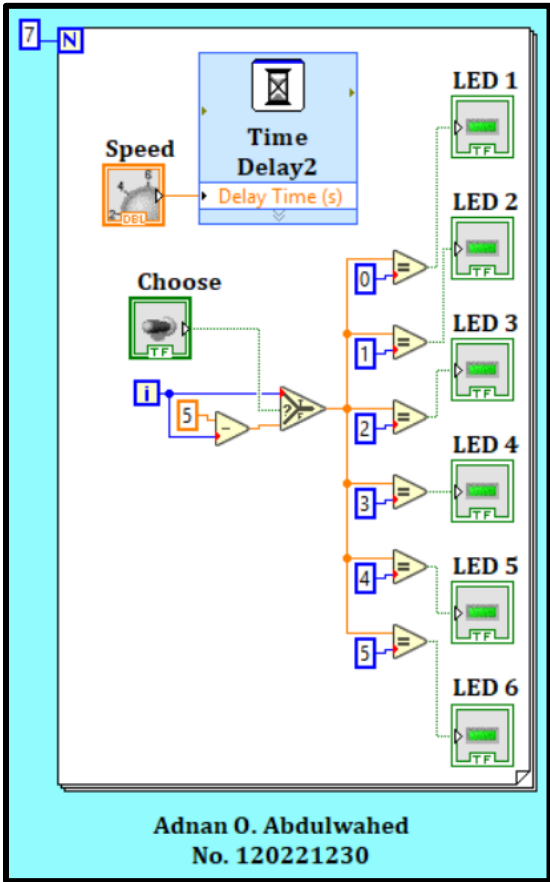
Block Diagram



B. Front Panel



Block Diagram



The Islamic University - Gaza
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Linear Control Lab
“HW 5”

Student Name:
Adnan Osama Abdulwahed

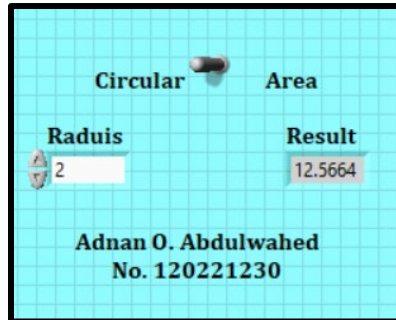
Student ID: 120221230

Supervisor:
Eng. Nael Dokhan

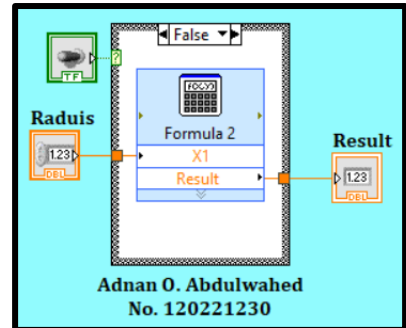
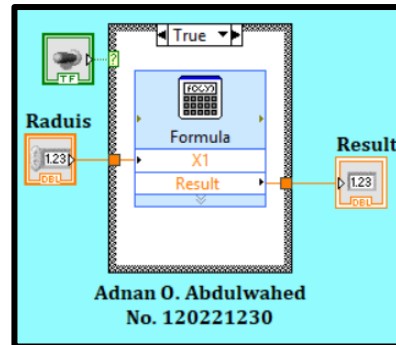
Question 1: Two Examples in Lab:

A.

Front Panel

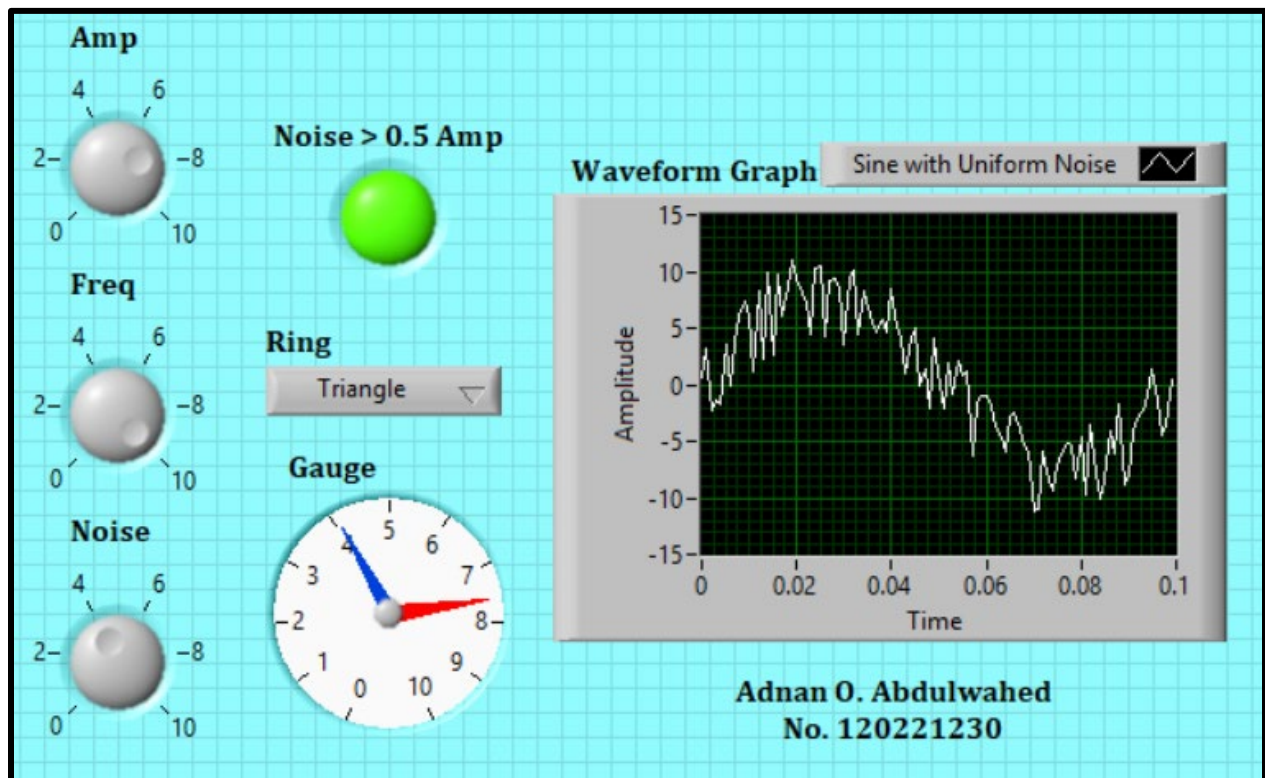


Block Diagram

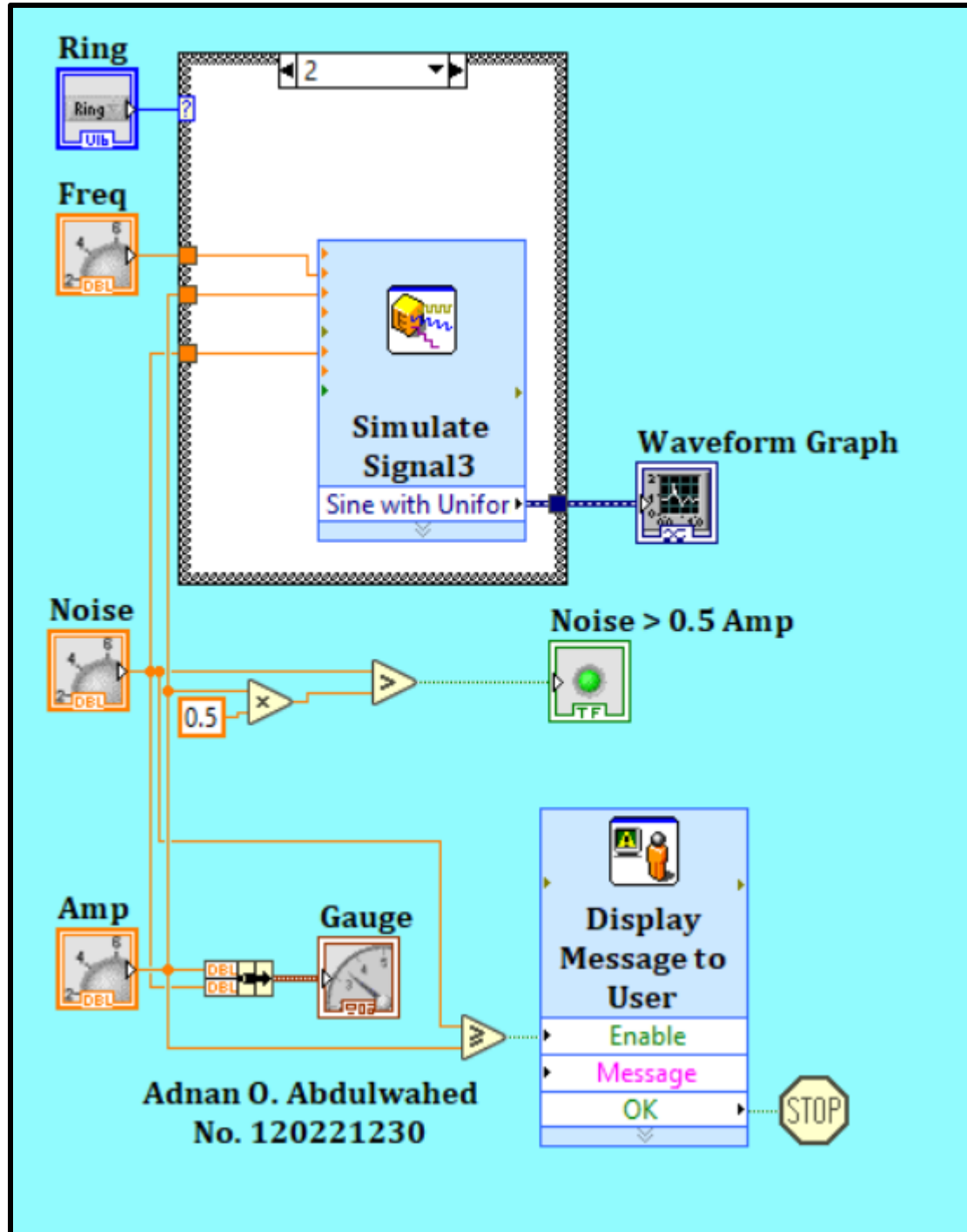


B.

Front Panel

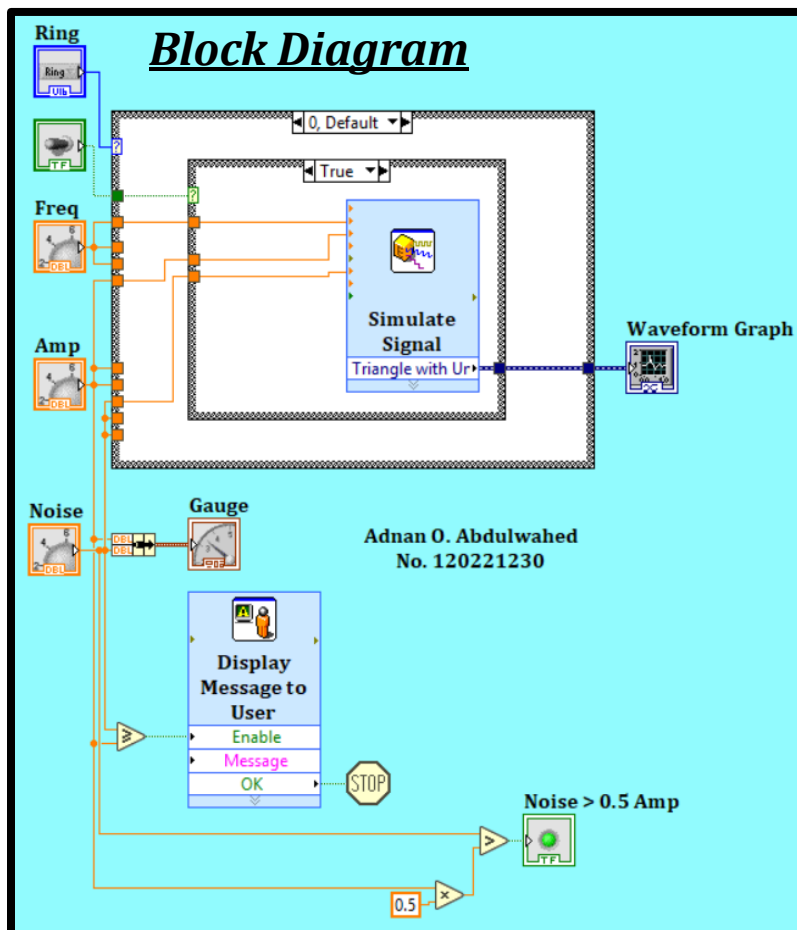
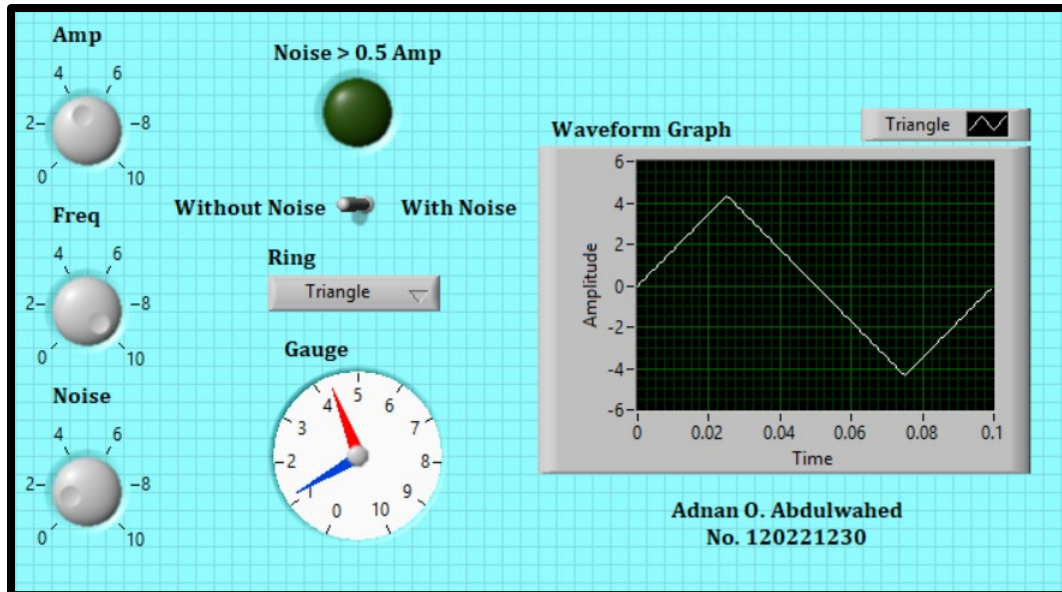


Block Diagram



Question 2: Lab work:

A. Front Panel



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Linear Control Lab
“HW 6”

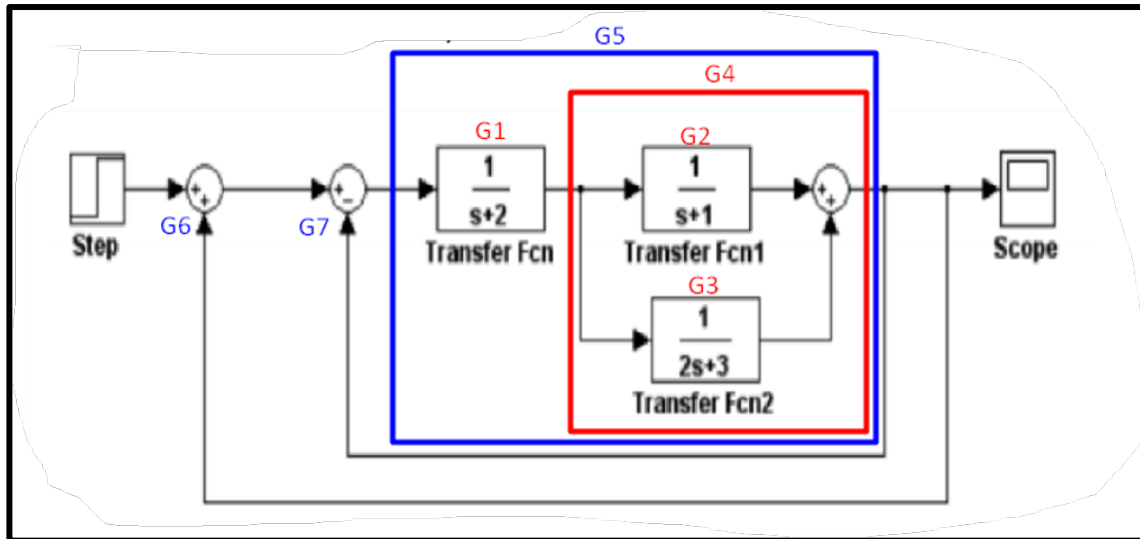
Student Name:
Adnan Osama Abdulwahed

Student ID: 120221230

Supervisor:
Eng. Nael Dokhan

Question 1: Using MATLAB:

A.



a. Find the transfer function of the system.

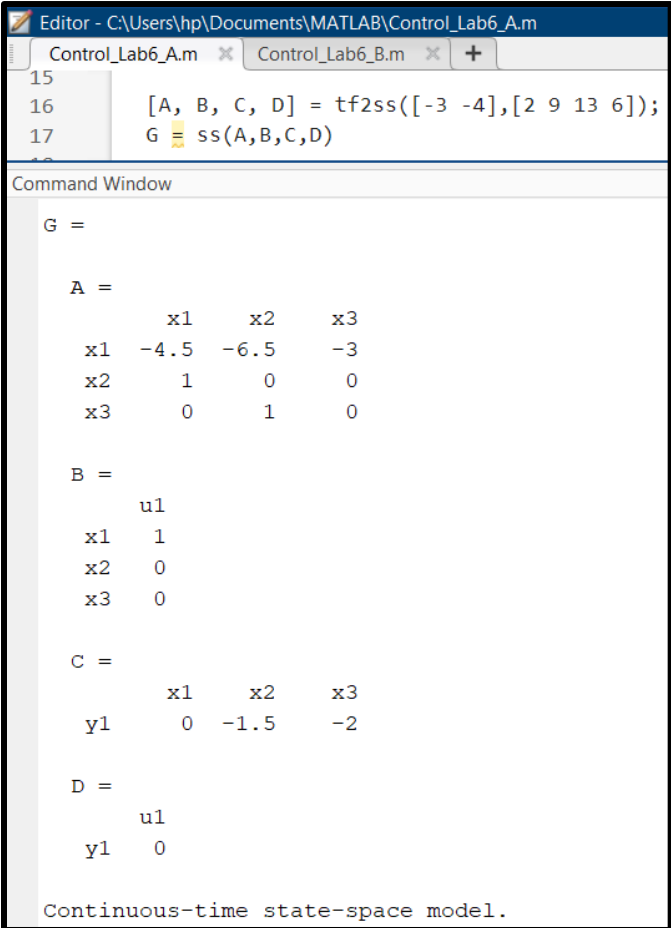
```
Editor - C:\Users\hp\Documents\MATLAB\Control_Lab6_A.m
Control_Lab6_A.m  Control_Lab6_B.m  +
1      num1 = [0 1];
2      den1 = [1 2];
3      G1 = tf(num1,den1);
4      num2 = [0 1];
5      den2 = [1 1];
6      G2 = tf(num2,den2);
7      num3 = [0 1];
8      den3 = [2 3];
9      G3 = tf(num3,den3);
10     G4 = parallel(G2,G3);
11     G5 = series(G1,G4);
12     G7 = feedback(G5,1);
13     G6 = feedback(G7,-1)
```

Command Window

G6 =

$$\frac{3s + 4}{2s^3 + 9s^2 + 13s + 6}$$

b. Then, find the state-space of the system.



The image shows a MATLAB Editor window with two tabs: 'Control_Lab6_A.m' and 'Control_Lab6_B.m'. The 'Control_Lab6_A.m' tab is active, showing the following code:

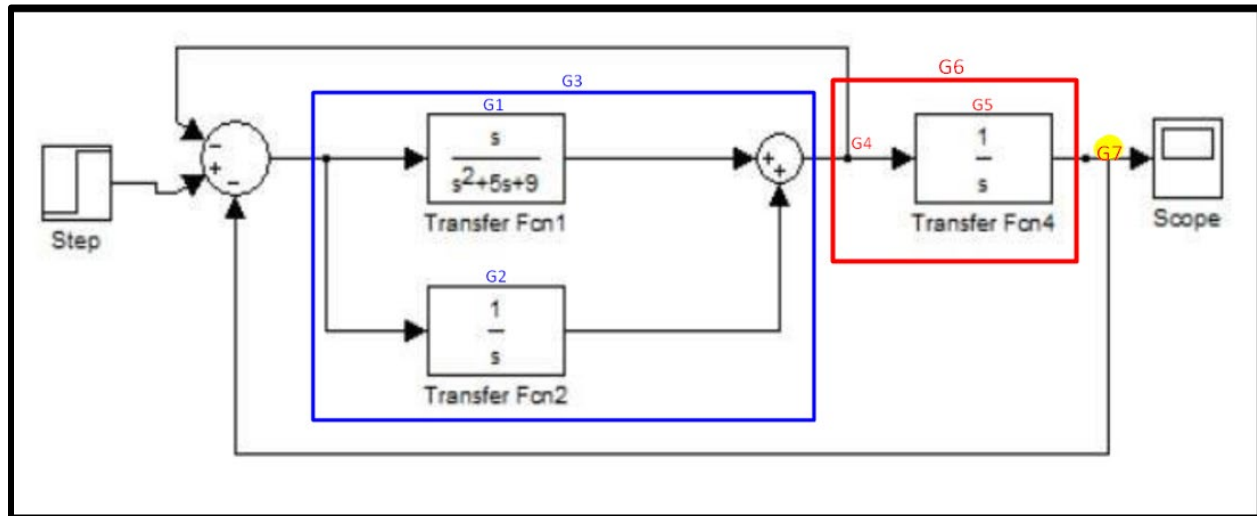
```
15  
16 [A, B, C, D] = tf2ss([-3 -4],[2 9 13 6]);  
17 G = ss(A,B,C,D)
```

Below the editor is the Command Window, which displays the resulting state-space matrices:

```
G =  
  
A =  
      x1      x2      x3  
x1 -4.5  -6.5  -3  
x2   1     0     0  
x3   0     1     0  
  
B =  
      u1  
x1   1  
x2   0  
x3   0  
  
C =  
      x1      x2      x3  
y1   0  -1.5  -2  
  
D =  
      u1  
y1   0
```

At the bottom of the Command Window, it says: "Continuous-time state-space model."

B.



a. Find the transfer function of the system.

```

Editor - C:\Users\hp\Documents\MATLAB\Control_Lab6_B.m *
Control_Lab6_A.m  Control_Lab6_B.m *  +
1      num1 = [1 0];
2      den1 = [1 5 9];
3      G1 = tf(num1,den1);
4      num2 = [0 1];
5      den2 = [1 0];
6      G2 = tf(num2,den2);
7      G3 = parallel(G1,G2);
8      G4 = feedback(G3,1);
9      num3 = [0 1];
10     den3 = [1 0];
11     G5 = tf(num3,den3);
12     G6 = series(G4,G5);
13     G7 = feedback(G6,1)

Command Window

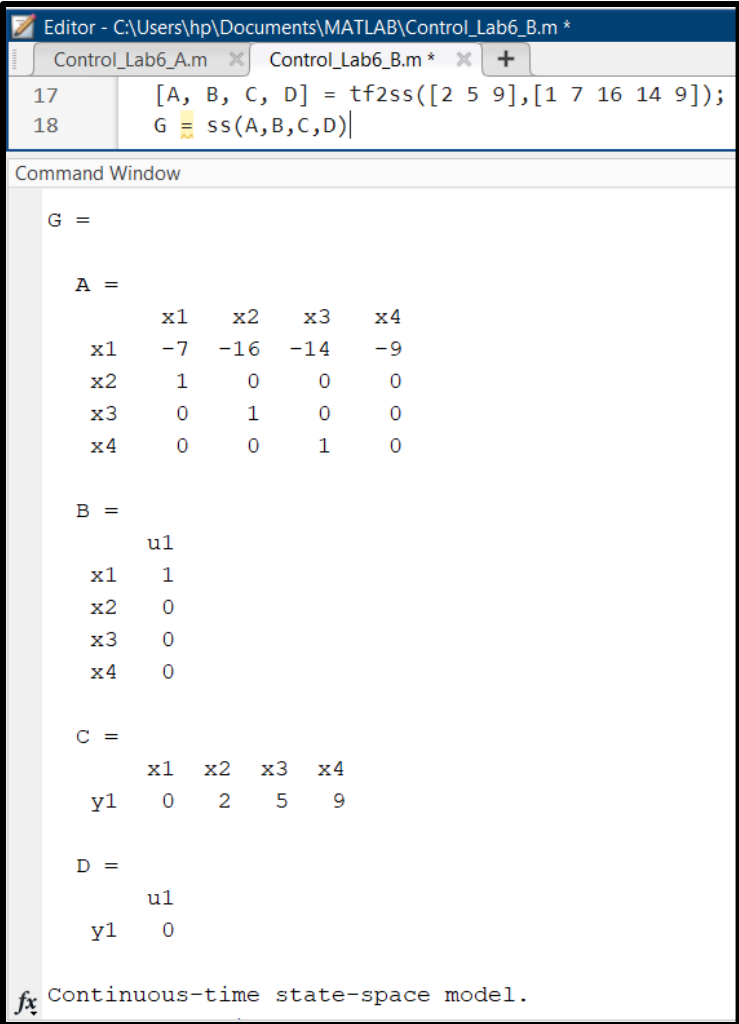
G7 =

          2 s^2 + 5 s + 9
-----
s^4 + 7 s^3 + 16 s^2 + 14 s + 9

Continuous-time transfer function.

```

b. Then, find the state-space of the system.



The image shows a MATLAB Editor window with two tabs: 'Control_Lab6_A.m' and 'Control_Lab6_B.m *'. The active tab 'Control_Lab6_B.m' contains the following code:

```
17 [A, B, C, D] = tf2ss([2 5 9],[1 7 16 14 9]);
18 G = ss(A,B,C,D)
```

Below the editor is the Command Window, which displays the resulting state-space matrices:

```
G =

A =

    x1    x2    x3    x4
x1   -7   -16   -14   -9
x2    1    0    0    0
x3    0    1    0    0
x4    0    0    1    0

B =

    u1
x1    1
x2    0
x3    0
x4    0

C =

    x1    x2    x3    x4
y1    0     2     5     9

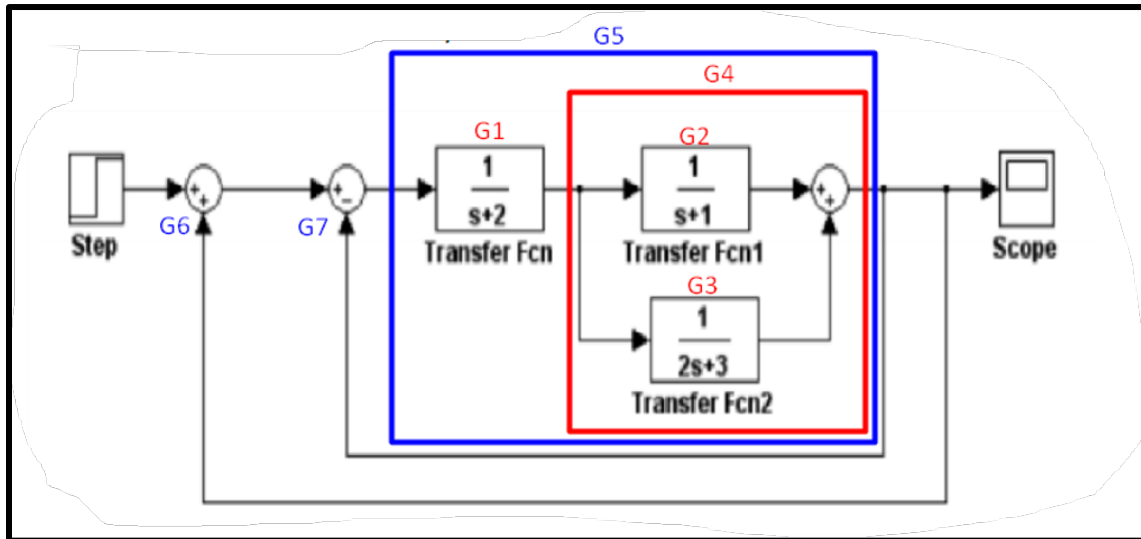
D =

    u1
y1    0
```

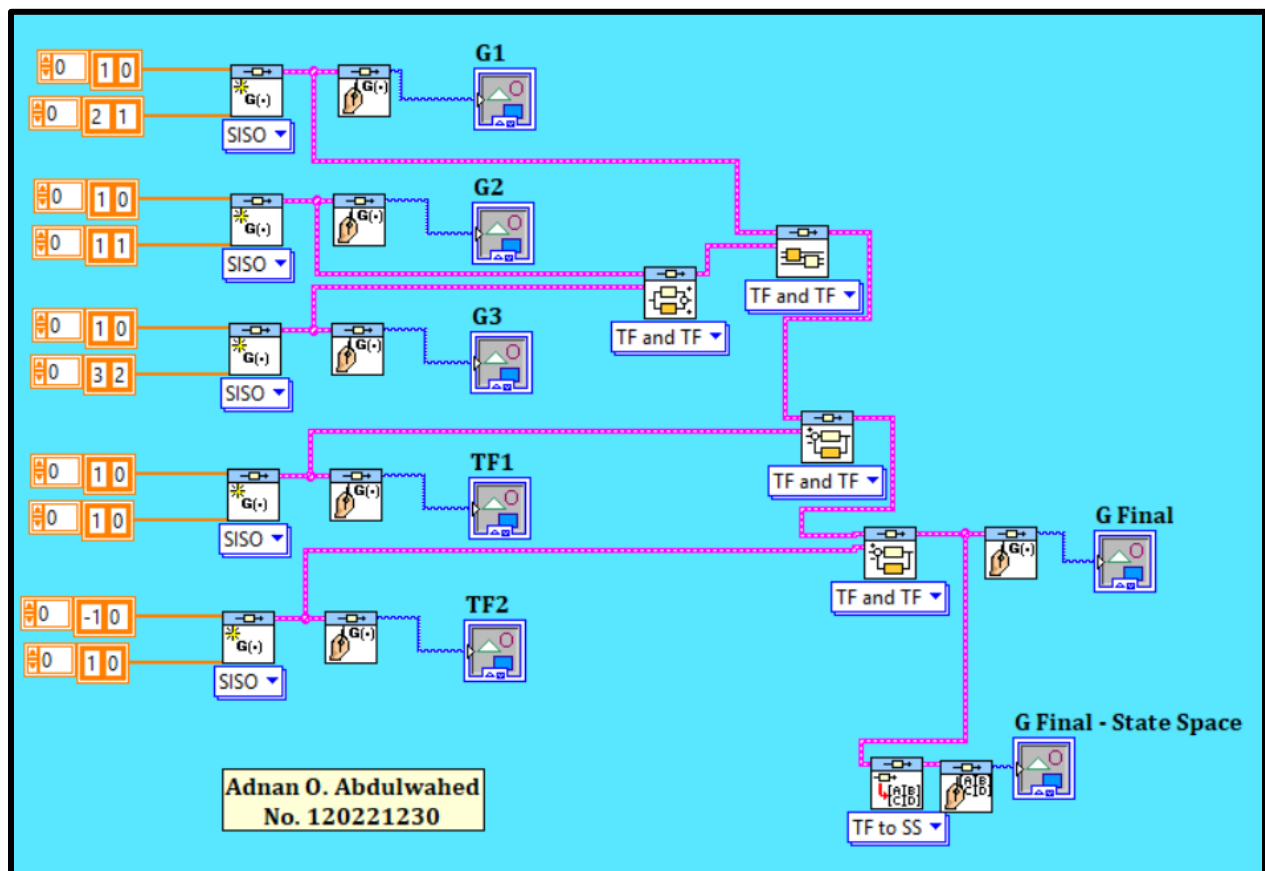
At the bottom of the Command Window, it says: *fx* Continuous-time state-space model.

Question 1: Using LabVIEW:

A.



Block Diagram



Front Panel

G1

$$\frac{1}{s+2}$$

G2

$$\frac{1}{s+1}$$

G3

$$\frac{1}{2s+3}$$

TF1

$$1$$

TF2

$$-1$$

G Final

$$\frac{3s+4}{2s^3+9s^2+13s+6}$$

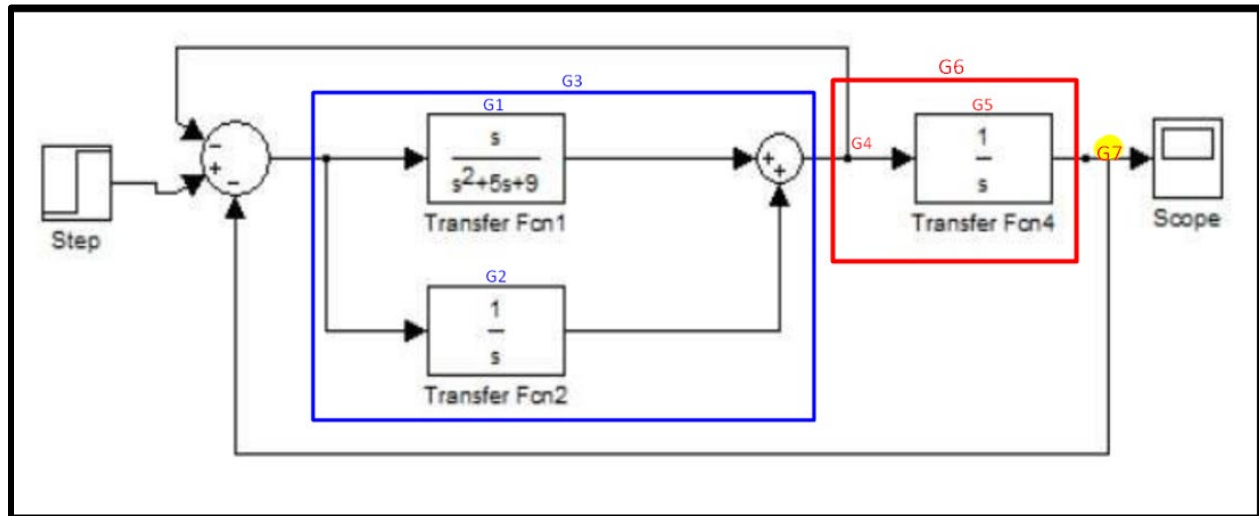
G Final - State Space

$$\frac{dx}{dt} = \begin{bmatrix} -4.5 & -1.625 & -0.75 \\ 4 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \mathbf{x}(t) + \begin{bmatrix} 0.25 \\ 0 \\ 0 \end{bmatrix} \mathbf{u}(t)$$

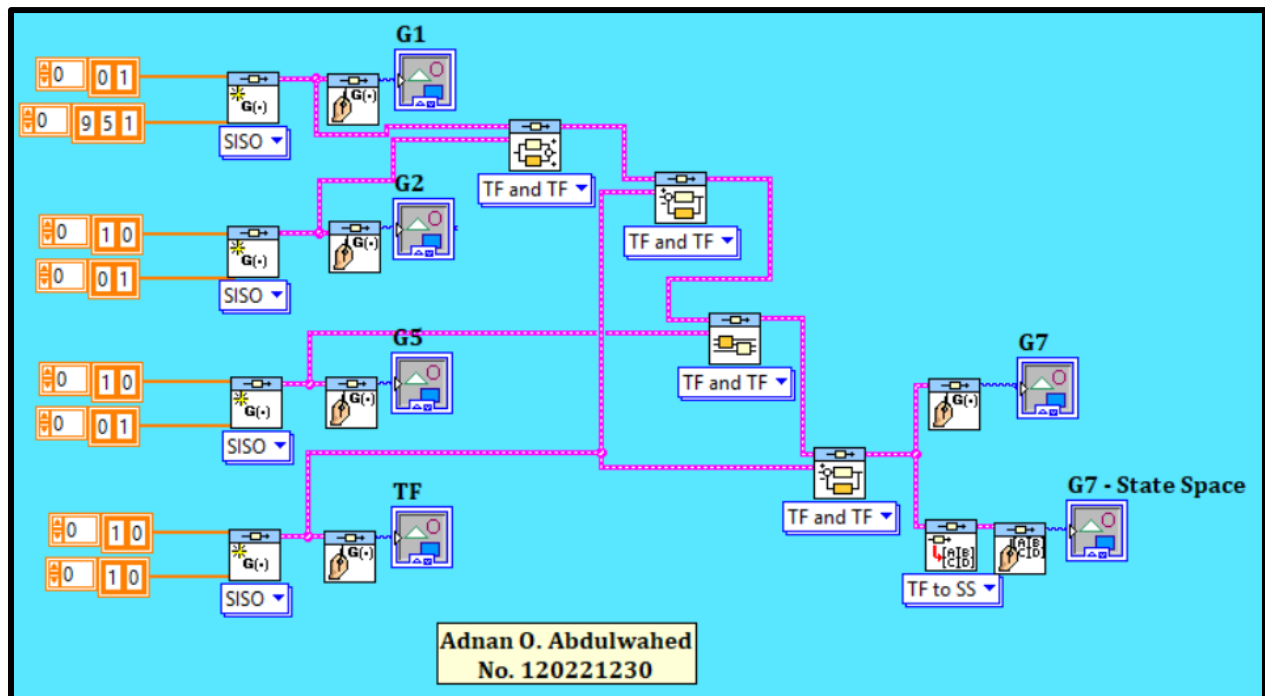
$$\mathbf{y}(t) = \begin{bmatrix} 0 & 1.5 & 2 \end{bmatrix} \mathbf{x}(t) + \begin{bmatrix} 0 \end{bmatrix} \mathbf{u}(t)$$

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No. 120221230

B.



Block Diagram



Front Panel

G1

$$\frac{s}{s^2 + 5s + 9}$$

G2

$$\frac{1}{s}$$

G5

$$\frac{1}{s}$$

TF

$$1$$

G7

$$\frac{2s^2 + 5s + 9}{s^4 + 7s^3 + 16s^2 + 14s + 9}$$

G7 - State Space

$$\frac{dx}{dt} = \begin{bmatrix} -7 & -4 & -1.75 & -1.125 \\ 4 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \mathbf{x}(t) + \begin{bmatrix} 0.125 \\ 0 \\ 0 \\ 0 \end{bmatrix} \mathbf{u}(t)$$

$$\mathbf{y}(t) = \begin{bmatrix} 0 & 4 & 5 & 9 \end{bmatrix} \mathbf{x}(t) + \begin{bmatrix} 0 \end{bmatrix} \mathbf{u}(t)$$

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Linear Control Lab
“HW 7”

Student Name:
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Supervisor:
Eng. Nael Dokhan

Exercises (1): for the following system:

$$H(s) = \frac{2}{s^2 + 2\zeta\omega_n s + 1}$$

- ✚ Let $\omega_n = 1$, Obtain the poles of the system for $\xi = 0, 0.1, 0.7, 1, 5$ and guess the behavior of step response for every value with explanation.
- ✚ Plot the step response for every ξ above on the same figure and obtain the behavior of it from the graph.
- ✚ Let $\omega_n = 1, \xi = 0.8$. Plot the step response and obtain the OS%, Ts, Tr, S.S.E & DC gain by :
 1. From the graph.

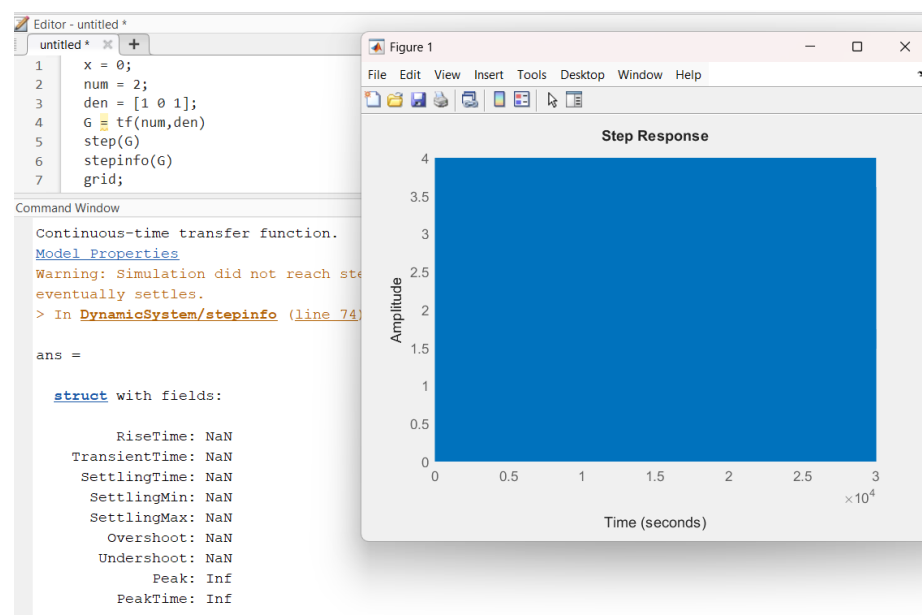
$$H(s) = \frac{2}{s^2 + 2\xi s + 1}$$

I will solve parts one and two of the question and include a plot for each value of ξ .

1- $\xi = 0$:

$$s_{1,2} = -\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2} = \pm j.$$

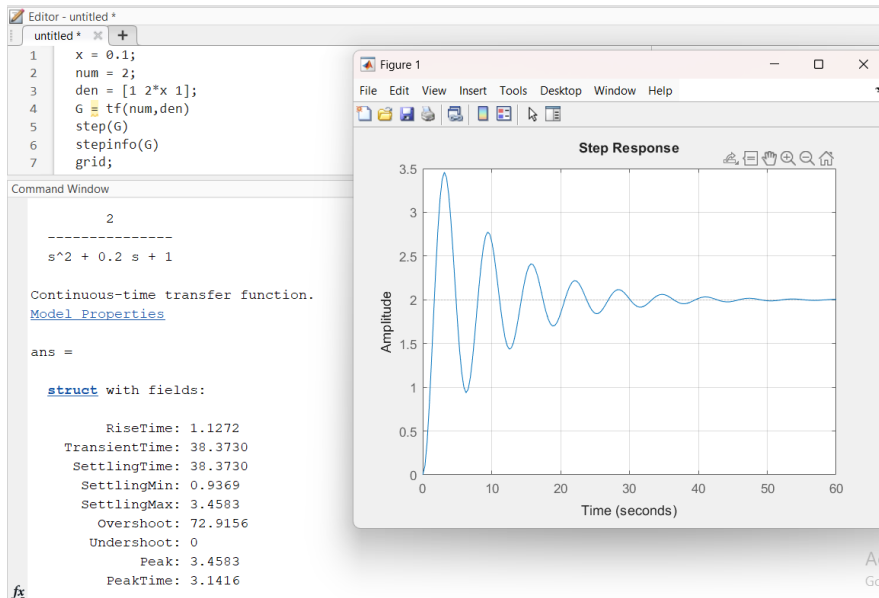
The behavior = Undamped responses



2- $\xi = 0.1$:

$$S_{1,2} = -\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2} = -0.1 \pm j0.994.$$

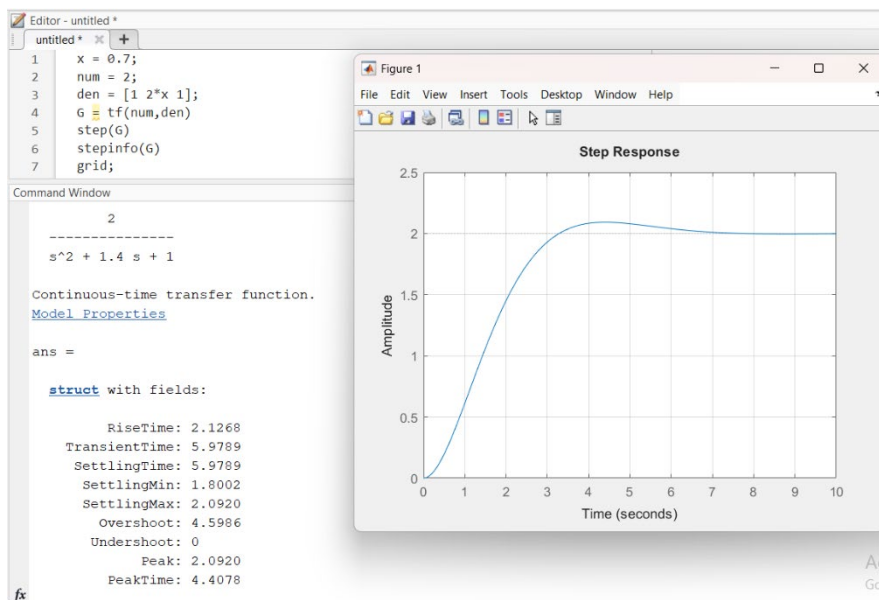
The behavior = Underdamped responses



3- $\xi = 0.7$:

$$S_{1,2} = -\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2} = -0.7 \pm j0.714.$$

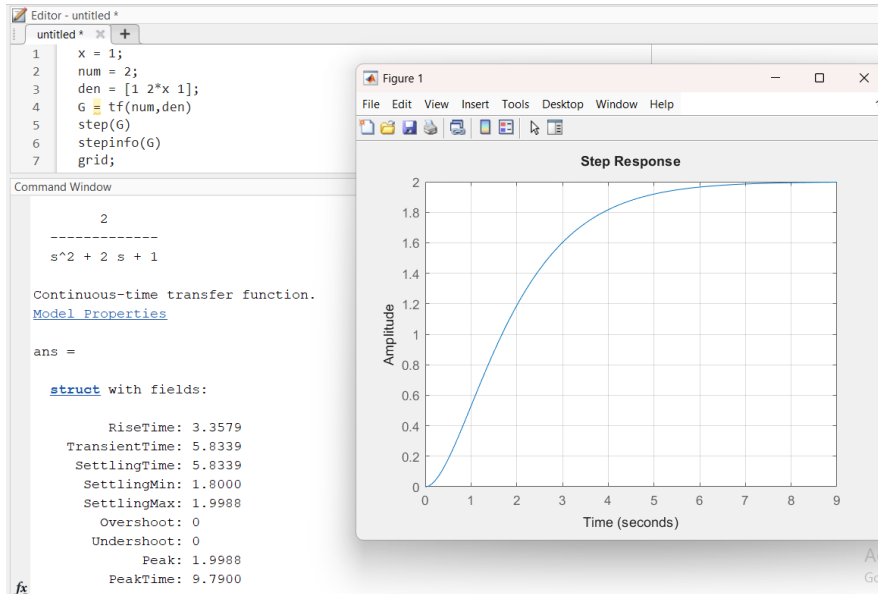
The behavior = Underdamped responses



4- $\xi = 1$:

$$S_{1,2} = -\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2} = -1.$$

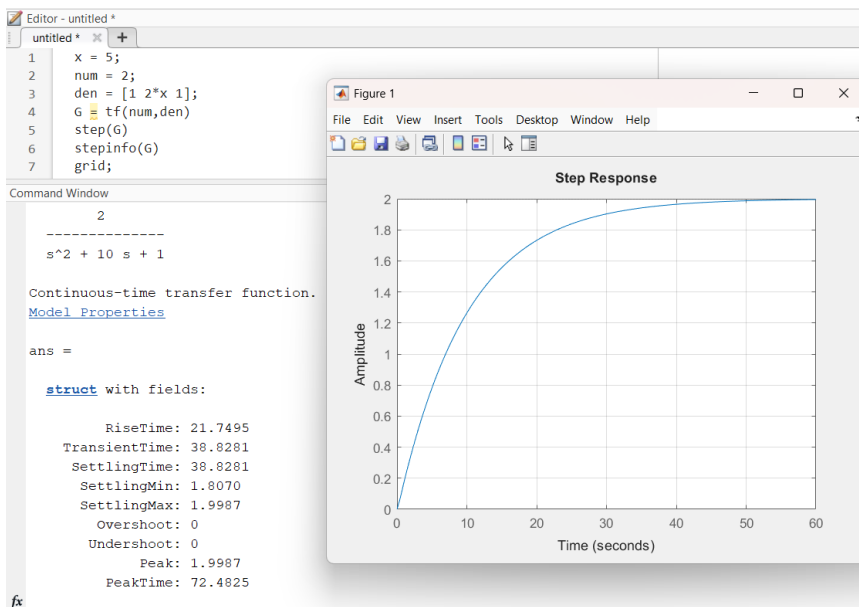
The behavior = Critically damped responses



5- $\xi = 5$:

$$S_{1,2} = -\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2} = -5 \pm j\sqrt{1-5^2} = -5 \pm (-2\sqrt{6}).$$

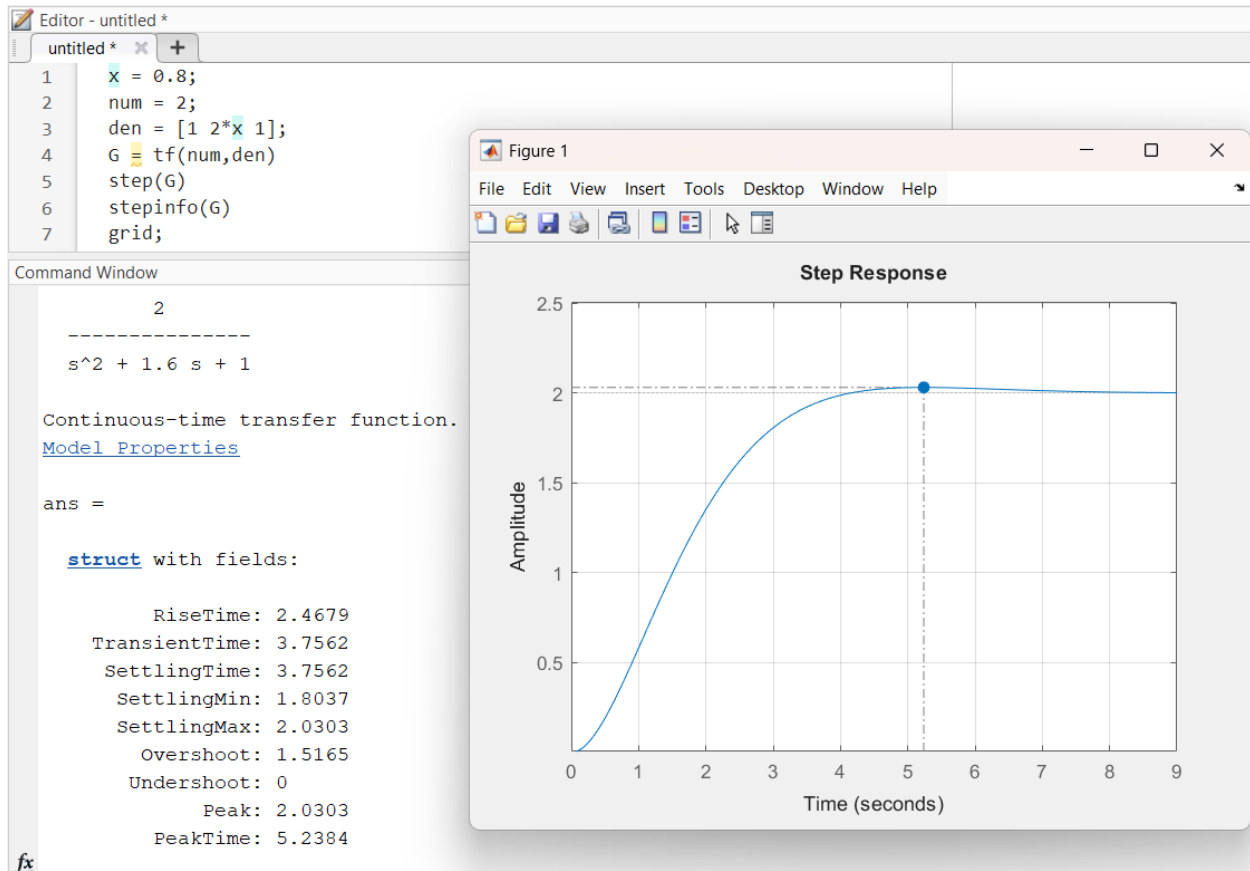
The behavior = Overdamped Responses.



Part 3 of the question:

Let $\omega_n = 1$, $\xi = 0.8$. Plot the step response and obtain the OS%, Ts, Tr, S.S.E & DC gain by :

1. From the graph.



Exercise (2): consider the transfer function below describes an elevator system:

$$H(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

For this system we want some specifications to be suitable to users:

- ✓ Percent overshooting less than 10% (do not shock the users at beginning).
- ✓ Settling time less than 4 sec (don't make users feel boring).

Design the system by finding ξ and ω_n , and then give the step response of the complete transfer function of the system to make sure from the plot.

$$OS\% < 10\%$$

$$OS\% = e^{\frac{\pi\xi}{\sqrt{1-\xi^2}}} * 100 < 10\%$$

$$\xi \geq \frac{(\ln 0.1)^2}{\pi^2 + (\ln 0.1)^2} = 0.591$$

$$T_s < 4$$

$$T_s = \frac{4}{\xi\omega_n} < 4$$

$$\xi\omega_n > 1 \rightarrow \omega_n > \frac{1}{\xi}$$

So I choice for Design: $\xi = 0.6$, $\omega_n = 2$

$$H(S) = \frac{4}{S^2 + 2.4S + 4}$$

```

Editor - untitled *
Control_Lab7.m  untitled *  +
1  num = 4;
2  den = [1 2.4 4];
3  G = tf(num,den)
4  step(G)
5  stepinfo(G)
6  grid;

Command Window

      4
-----
s^2 + 2.4 s + 4

Continuous-time transfer function.
Model Properties

ans =

struct with fields:

    RiseTime: 0.9278
  TransientTime: 2.9717
    SettlingTime: 2.9717
    SettlingMin: 0.9083
    SettlingMax: 1.0948
    Overshoot: 9.4773
    Undershoot: 0
         Peak: 1.0948
    PeakTime: 1.9572
  
```

