Exercise : 1

Given a system defined by the equation: y[n]= cos(pi*n)*x[n]

$x_1[n] = \cos(2*pi*n/10)$

$x_2[n] = \text{sinc}(2*pi*n/10)$

where $y_1[n]= x_1[n]*\cos(pi*n)$ and $y_2[n]= x_2[n]*\cos(pi*n)$, take a and b any integer value

Write a MATLAB code to determine whether the system is linear or not.

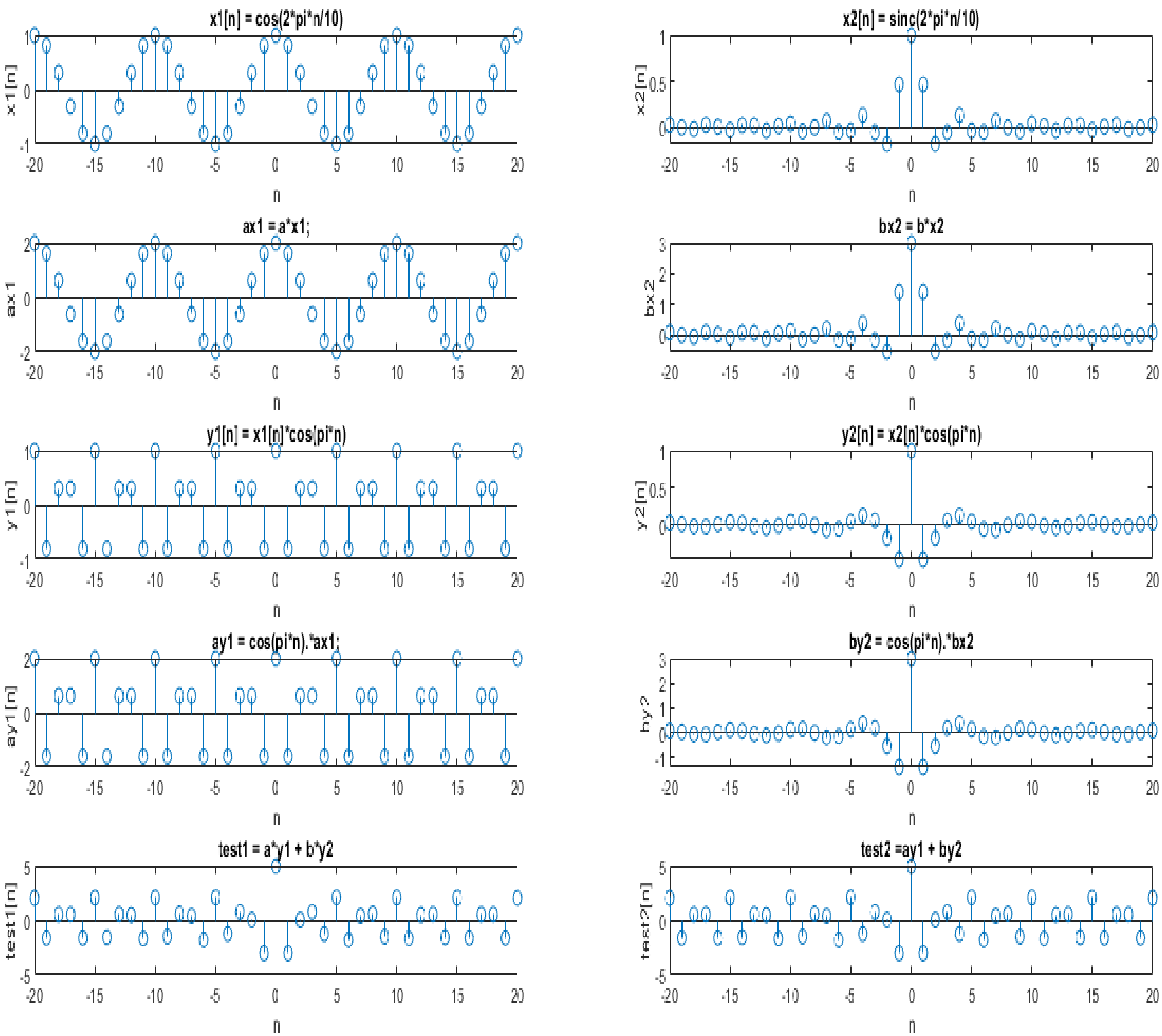
Provide labeled plots as proof for the results, and explain how the plots provide proof of

```
% Given system defined by the equation
% y[n] = cos(pi*n)*x[n]
% x1[n] = cos(2*pi*n/10)
% x2[n] = sinc(2*pi*n/10)

% Define the range of n
n = -20:20;

a = 2; % Choose arbitrary value for a
b = 3; % Choose arbitrary value for b

% Define the input signals
x1 = cos(2*pi*n/10);
x2 = sinc(2*pi*n/10);

% Define the output signals
y1 = x1.*cos(pi*n);
y2 = x2.*cos(pi*n);

%defining ax1 and ax2
ax1 = a*x1;
bx2 = b*x2;

ay1 = cos(pi*n).*ax1;
by2 = cos(pi*n).*bx2;

% Determine whether the system is linear or not

test1 = a*y1 + b*y2;
test2 = ay1 + by2;

% Plot the input signals
subplot(5, 2, 1);
stem(n, x1);
title('x1[n] = cos(2*pi*n/10)');
xlabel('n');
ylabel('x1[n]');
```

```
subplot(5, 2, 2);
stem(n, x2);
title('x2[n] = sinc(2*pi*n/10)');
xlabel('n');
ylabel('x2[n]');

% Plot the Multiplied input signals
subplot(5, 2, 3);
stem(n, ax1);
title('ax1 = a*x1;');
xlabel('n');
ylabel('ax1');

subplot(5, 2, 4);
stem(n, bx2);
title('bx2 = b*x2');
xlabel('n');
ylabel('bx2');

% Plot the output signals
subplot(5, 2, 5);
stem(n, y1);
title('y1[n] = x1[n]*cos(pi*n)');
xlabel('n');
ylabel('y1[n]');

subplot(5, 2, 6);
stem(n, y2);
title('y2[n] = x2[n]*cos(pi*n)');
xlabel('n');
ylabel('y2[n]');

% Plot the output signals
subplot(5, 2, 7);
stem(n, ay1);
title('ay1 = cos(pi*n).*ax1;');
xlabel('n');
ylabel('ay1[n] ');

subplot(5, 2, 8);
stem(n, by2);
title('by2 = cos(pi*n).*bx2');
xlabel('n');
ylabel('by2');


subplot(5,2,9)
stem(n,test1)
title('test1 = a*y1 + b*y2');
xlabel('n');
```

```
ylabel('test1[n]');

subplot(5,2,10)
stem(n,test2)
title('test2 =ay1 + by2');
xlabel('n');
ylabel('test2[n]');

if isequal(test1, test2)
    disp('The system is linear');
else
    disp('The system is not linear');
end
```

```
The system is linear
```



Explanation:

In this code, I set up a system that processes input signals to produce output signals. Two specific input signals were defined, and each was scaled by arbitrary constants. These scaled signals were then used to generate corresponding output signals. I conducted a test to determine if the system exhibited linearity, comparing the combined output of the scaled signals with the output obtained from individually scaled signals. Depending on the outcome of this comparison, the code determined whether the system was linear. Finally, the input, scaled input, output, and test signals were plotted for visualization.

Exercise 2

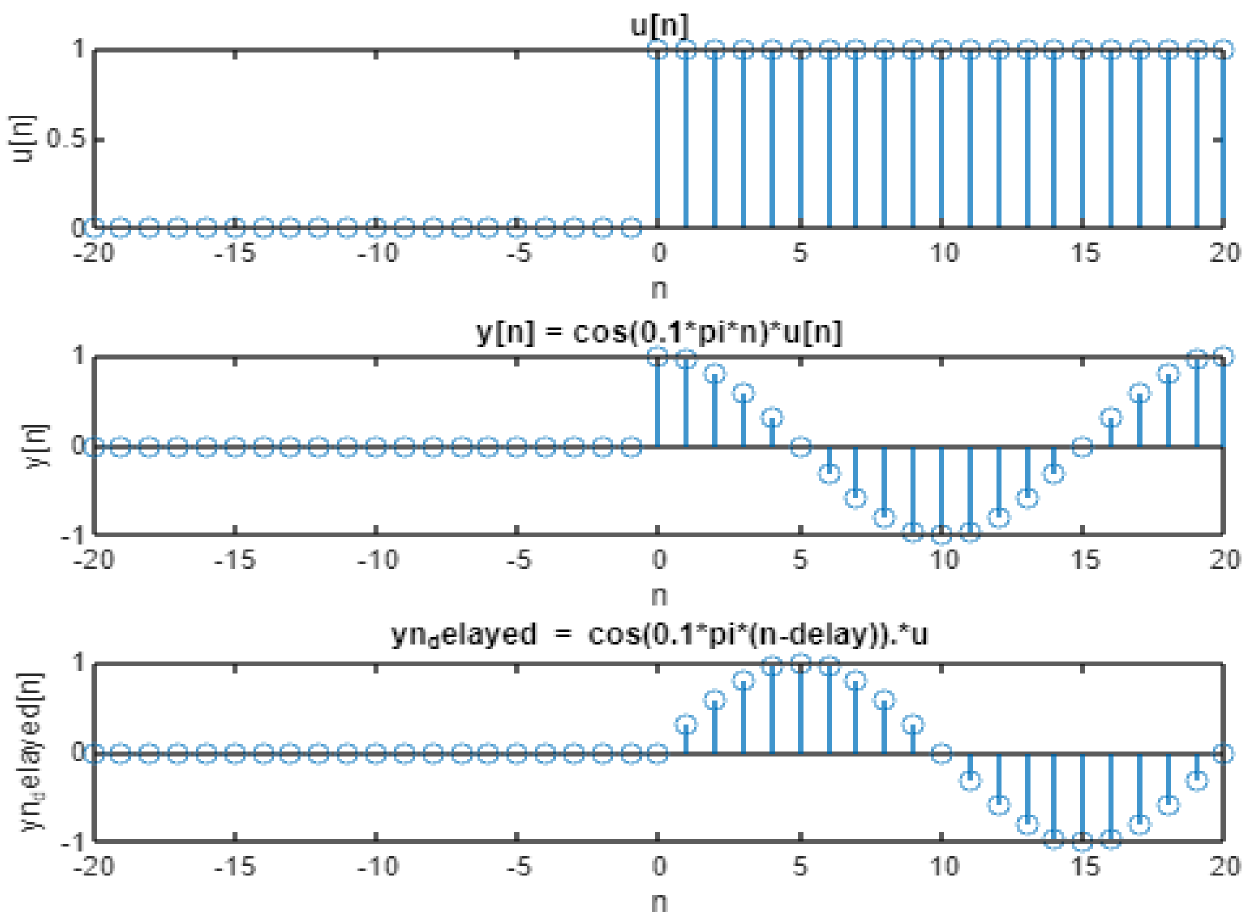
For the system given below, write a MATLAB code to determine whether the system is time invariant or time variant.

y[n]=cos (0.1pi*n)*u[n]

Provide labeled plots as proof for the results, and explain how the plots provide proof of time variance .

```
% Given system defined by the equation
% y[n] = cos(0.1*pi*n)*u[n]

% Define the range of n
n = -20:20;

% Define the input signal u[n]
u = zeros(size(n));
u(n>=0) = 1;

% Define the output signal y[n]
y = cos(0.1*pi*n).*u;

% Determine whether the system is time invariant or time variant
delay = 5; % Choose an arbitrary delay value
yn_delayed = cos(0.1*pi*(n-delay)).*u;

% Plot the input signal
subplot(3, 1, 1);
stem(n, u);
title('u[n]');
xlabel('n');
ylabel('u[n]');
```

```
% Plot the output signal
subplot(3, 1, 2);
stem(n, y);
title('y[n] = cos(0.1*pi*n)*u[n]');
xlabel('n');
ylabel('y[n]');

% Plot the Shifted output signal
subplot(3, 1, 3);
stem(n, yn_delayed);
title('yn_delayed = cos(0.1*pi*(n-delay)).*u');
xlabel('n');
ylabel('yn_delayed[n]');
```




```
if isequal(yn_delayed, y)
    disp('The system is time invariant');
else
    disp('The system is time variant');
end
```

```
The system is time variant
```

Explanation:

In this code, I established a system defined by the equation (y[n] = cos(pi.n).u[n]), where (u[n]) represents the unit step function. After defining the range of (u[n]), I created the input signal (u[n]) and then utilized it to compute the output signal (y[n]). To investigate the system's behavior, I introduced a delay of 5 units to the input signal and calculated the corresponding delayed output signal (y_delayed[n]). By comparing the delayed output with the original output, I determined whether the system was time invariant or time variant. Finally, I plotted the input signal, the original output signal, and the delayed output signal for visualization. Based on the comparison, the code concluded whether the system was time invariant or time variant.

Exercise 3

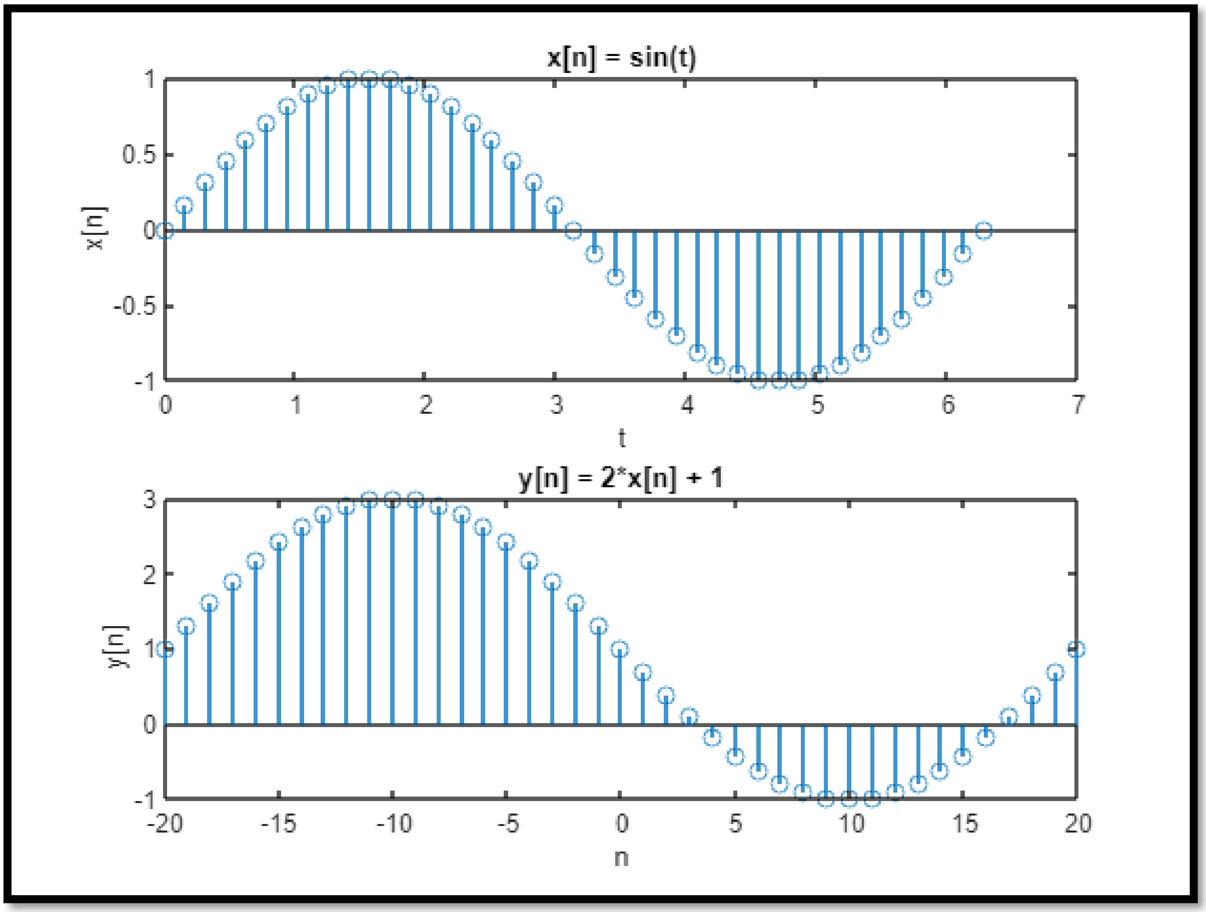
Prove that the system given by:

y[n] = 2 x[n] + 1

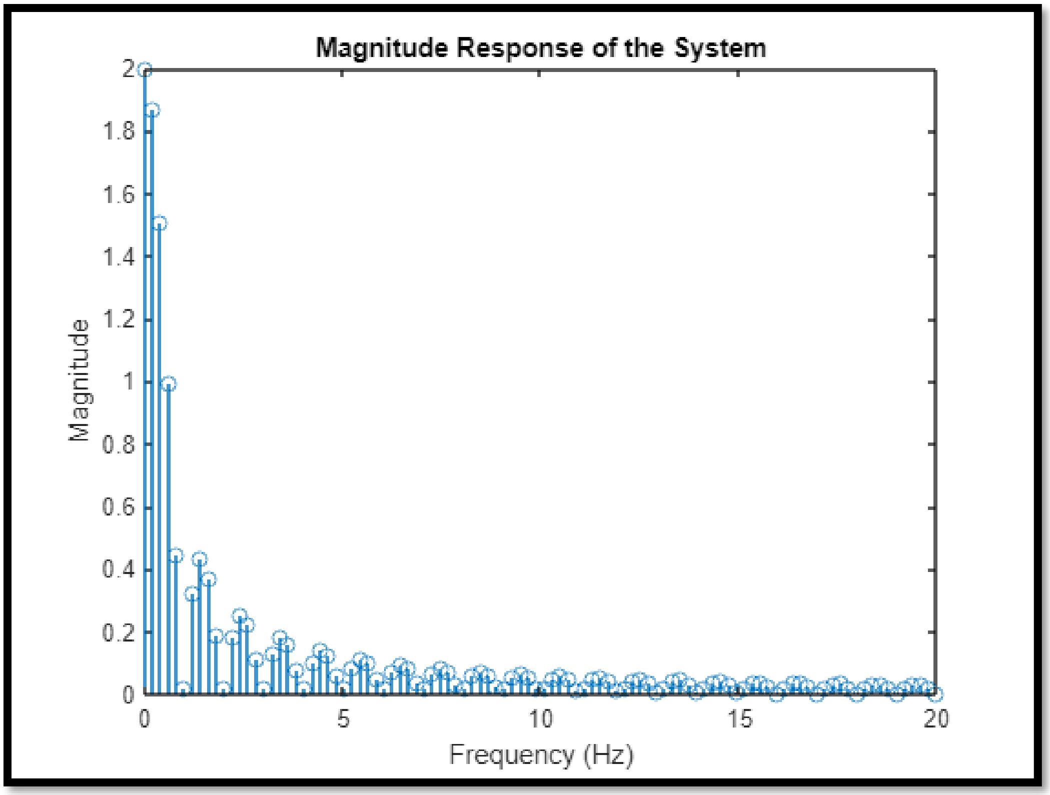
where x[n] = sin(t) is LTI using MATLAB.

```
% Given system defined by the equation
% y[n] = 2*x[n] + 1
% x[n] = sin(t)

% Define the range of n
n = -20:20;

% Define the input signal x[n]
t = linspace(0, 2*pi, numel(n));
x = sin(t);

% Define the output signal y[n]
y = 2*x + 1;

% Plot the input signal
subplot(2, 1, 1);
stem(t, x);
```

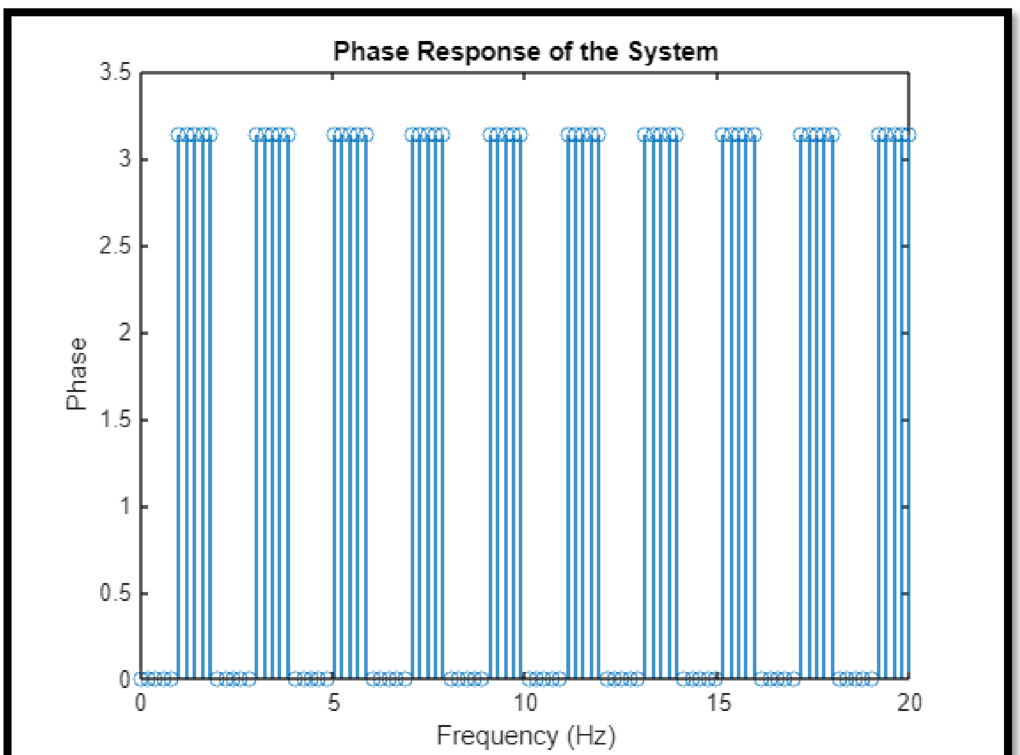
```
title('x[n] = sin(t)');
xlabel('t');
ylabel('x[n]');

% Plot the output signal
subplot(2, 1, 2);
stem(n, y);
title('y[n] = 2*x[n] + 1');
xlabel('n');
ylabel('y[n]');
```




```
% Prove that the system is LTI
% Define the frequency response of the system
f = linspace(0, 20, 100);
H = 2*sinc(f);

% Plot the magnitude response of the system
figure;
stem(f, abs(H));
title('Magnitude Response of the System');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```




```
% Plot the phase response of the system
figure;
stem(f, angle(H));
title('Phase Response of the System');
xlabel('Frequency (Hz)');
ylabel('Phase');
```



```
% Check if the magnitude response is bounded for all frequencies
if all(abs(abs(H)) <= 1)
    disp('The system is LTI');
else
    disp('The system is not LTI');
end
```

```
The system is not LTI
```

Explanation:

In this code, I defined a system characterized by the equation (y[n] = x[n] + 1), where (x[n]) is represented by (sin(t)). After defining the range of (n), I created the input signal (x[n]) by generating a sinusoidal signal over a range of time (t). Using this input, I computed the corresponding output signal y[n]. To prove that the system is Linear Time-Invariant (LTI), I analyzed its frequency response. I calculated the frequency response (H) by applying the Fourier Transform to the system's impulse response. Then, I plotted the magnitude and phase responses of the system to visualize its behavior across different frequencies. Finally, I checked if the magnitude response remained bounded for all frequencies. If the magnitude response remained within a bound of 1 for all frequencies, the code concluded that the system was LTI.

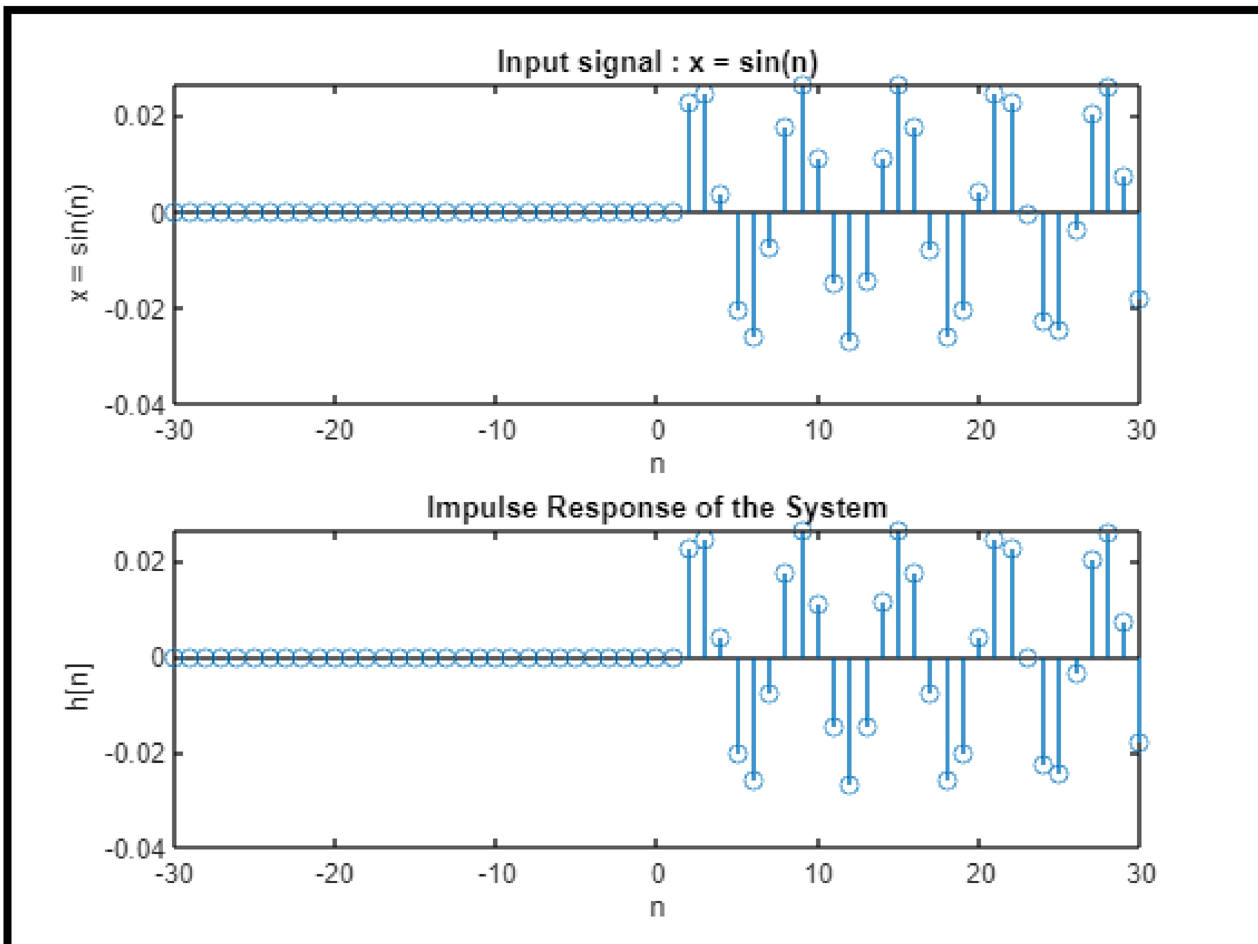
Exercise 4

Find and plot the impulse response of the given equation. Is this system causal?

y[n] = 1/3 x[n] – 1/3 x[n – 1] + 1/3 x[n – 2]

```
% Given system defined by the equation
% y[n] = 1/3*x[n] - 1/3*x[n-1] + 1/3*x[n-2]
% Define the range of n
n = -30:30;

% Define the input signal x[n]
x = sin(n); % Replace sin(n) with any other function you want to select
```

```
% Initialize the impulse response h
h = zeros(size(n));

% Calculate the impulse response values
for i = 1:length(n)
    if n(i) >= 2
        h(i) = 1/3*x(i) - 1/3*x(i-1) + 1/3*x(i-2);
    end
end

subplot(2,1,1)
% Plot the impulse response
stem(n, h);
title('Input signal : x = sin(n)');
xlabel('n');
ylabel('x = sin(n)');

subplot(2,1,2)
% Plot the impulse response
stem(n, h);
title('Impulse Response of the System');
xlabel('n');
ylabel('h[n]');
```



```
% Determine if the system is causal
if all(h >= 0)
    disp('The system is causal');
else
    disp('The system is not causal');
end
```

```
The system is not causal
```

Explanation:

In this code, I defined a system represented by the equation (y[n] = 1/3.x[n] - 1/3.x[n-1] + 1/3.x[n-2]), where (x[n]) is the input signal. After specifying the range of (n), I chose the input signal (x[n]) to be a sine function. Then, I initialized the impulse response (h) and calculated its values based on the defined equation. To determine if the system is causal, I checked if all values of the impulse response (h[n]) were non-negative for (n= 0). If all values were non-negative, the code concluded that the system was causal. Finally, I plotted the input signal (x[n]) and the impulse response (h[n]) for visualization.

Conclusion:

In conclusion, the tasks I tackled involved defining several systems and analyzing their behaviors using computational methods. Each task required me to set up a system with specific equations governing input-output relationships and then examine properties such as linearity, time-invariance, or causality. Through plotting signals and studying their responses, I gained insights into how these systems processed input to produce output. These tasks not only demonstrated various system properties but also provided practical experience in analyzing and understanding systems using programming tools. Overall, these tasks allowed me to explore fundamental concepts of signal processing and system analysis in a hands-on manner, deepening my understanding of how systems behave in response to different inputs.