LAB1 MATLAB Programming

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Contents

Introduction

After completing this lab, I'm able to,

1. Use MATLAB to represent impulse function, step function.

2. Use MATLAB to represent discrete-time signals.

3. Explore the effect of simple transformations of the independent variable, such as delaying the signal or reversing its time axis.

4. Use matlab to verify discrete-time systems' properties such as linearity, time invariance, stability, causality, and inverbily.

5. Use simple linear constant-coefficient difference equations (such as the first-order autoregression equation) to describe discrete-time systems.

Results and Analysis

1.4

(a)

For these problems, you are told which property a given system does not satisfy, and the input sequence or sequences that demonstrate clearly how the system violates the property. For each system, define MATLAB vectors representing the input(s) and output(s). Then, make plots of these signals, and construct a well reasoned argument explaining how these figures demonstrate that the system fails to satisfy the property in question.

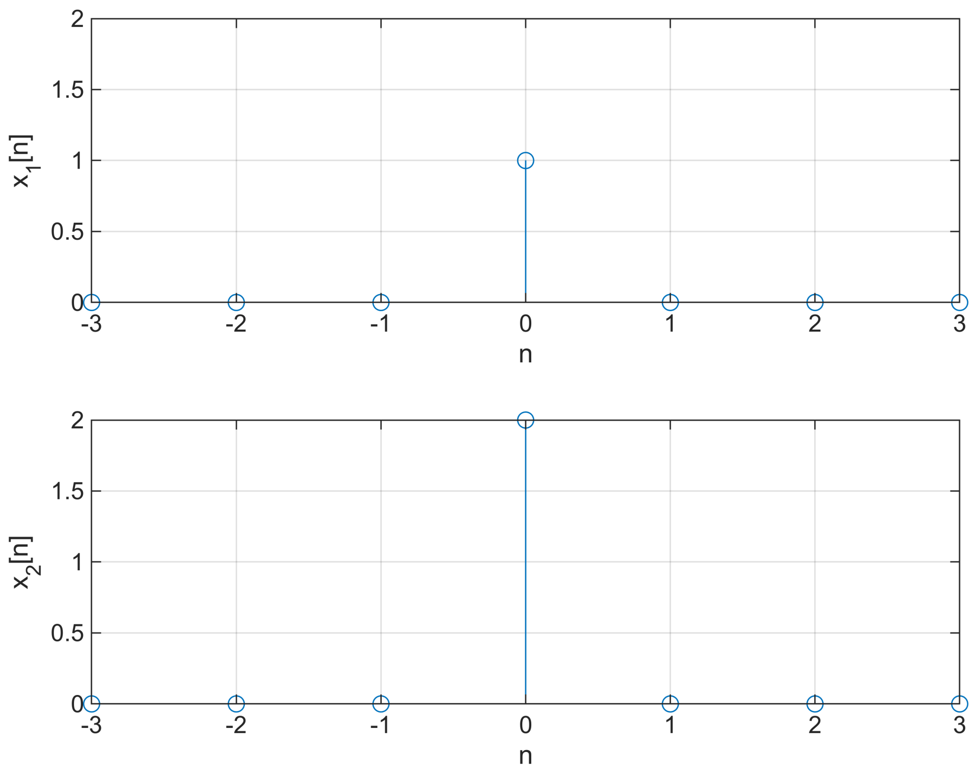
(a). The system $y[n] = \sin((\pi/2)x[n])$ is not linear. Use the signals $x_1[n] = \delta[n]$ and $x_2[n] = 2\delta[n]$ to demonstrate how the system violates linearity.

Initialize.

```
clear; clc; close all;
```

Create two vectors x_1 and x_2 and plot them.

```
n = -3:3;
x1 = unitimpulse(n);
x2 = 2*x1;
figure;
tiledlayout(2,1);
nexttile;
stem(n,x1);grid on;
xlabel('n');ylabel('x_1[n]');
axis([xlim,0 2]);
nexttile;
stem(n,x2);grid on;
xlabel('n');ylabel('x_2[n]');
axis([xlim,0 2]);
```

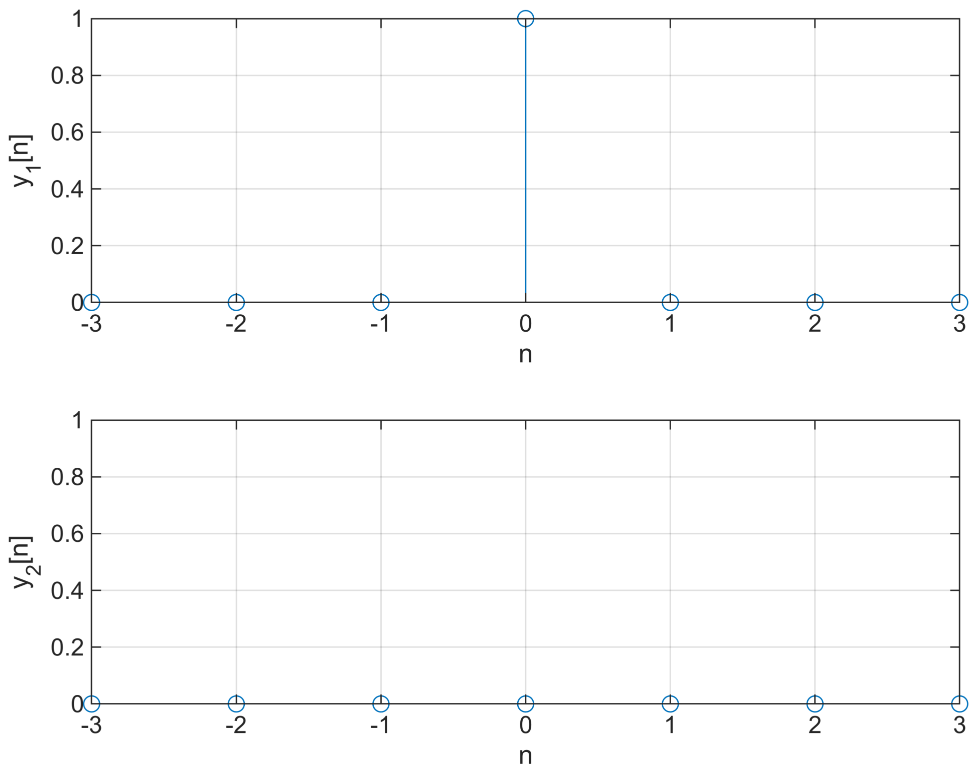


Calculate $y_1 = \sin\left(\frac{\pi}{2}x_1[n]\right)$ and $y_2 = \sin\left(\frac{\pi}{2}x_2[n]\right)$.

```
y1 = sin(pi/2*x1);
y2 = sin(pi/2*x2);
```

Plot and compare y_1 and y_2 .

```
figure;
tiledlayout(2,1);
nexttile;
stem(n,y1);grid on;
xlabel('n');ylabel('y_1[n]');
axis([xlim,0 1])
nexttile;
stem(n,y2);grid on;
xlabel('n');ylabel('y_2[n]');
axis([xlim,0 1]);
```



From the above figure, we know $x_2 = 2x_1$, but $y_2 \neq 2y_1$.

According to the definition, the system is not linear.

(b)

(b). The system $y[n] = x[n] + x[n+1]$ is not causal. Use the signal $x[n] = u[n]$ to demonstrate this. Define the MATLAB vectors **x** and **y** to represent the input on the interval $-5 \leq n \leq 9$, and the output on the interval $-6 \leq n \leq 9$, respectively.

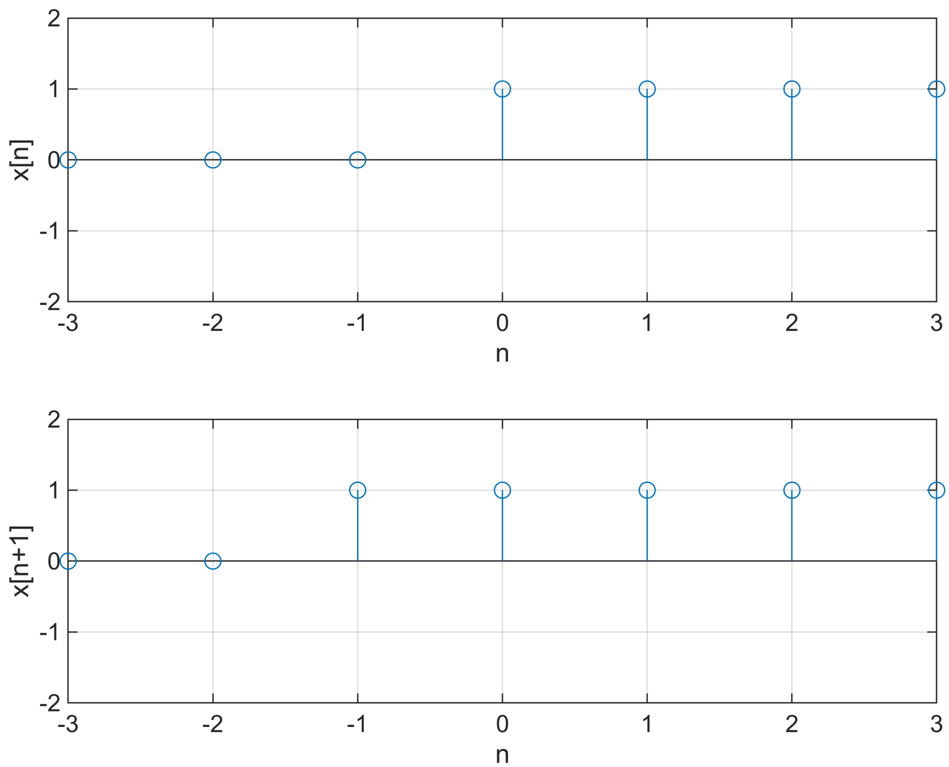
Initialize.

```
clear; clc; close all;
```

Create one vector x plot it.

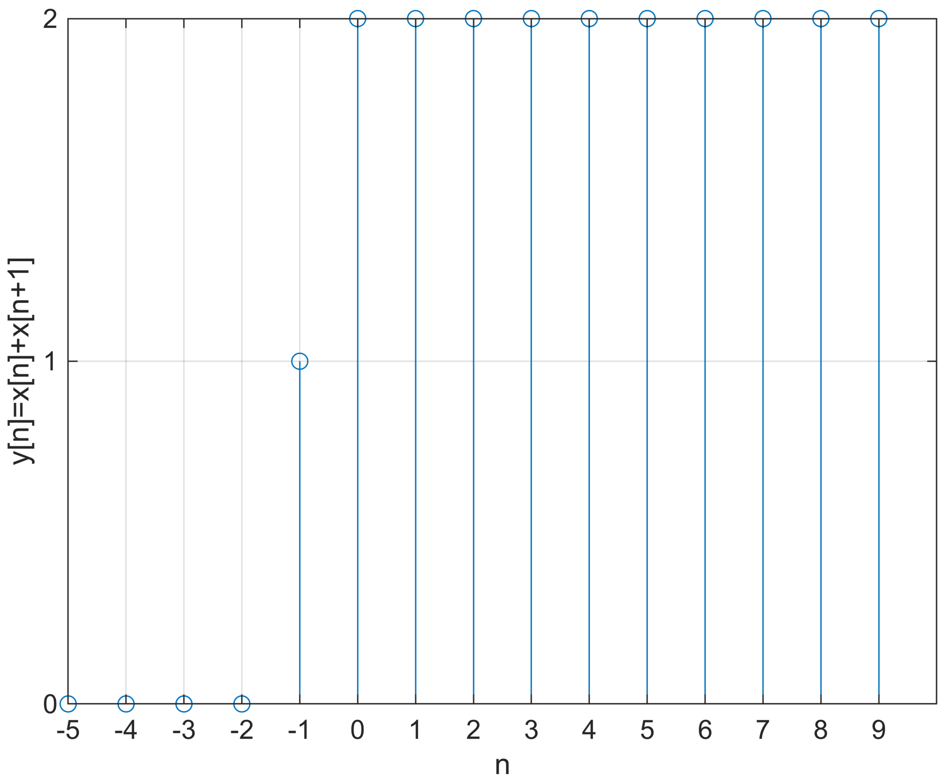
```
n = -5:9;
x1 = unitstep(n);
x2 = unitstep(n+1);
figure;
tiledlayout(2,1);
nexttile;stem(n,x1);axis([-3 3 -2 2]);grid on;
xlabel('n');ylabel('x[n]');
nexttile;stem(n,x2);axis([-3 3 -2 2]);grid on;
```

```
xlabel('n');ylabel('x[n+1]');
```



Calculate $y[n] = x[n] + x[n+1]$.

```
y = x1 + x2;
figure;
stem(n,y);
xlabel('n');
ylabel('y[n]=x[n]+x[n+1]');
xticks(n);
yticks([0 1 2]);
grid on;
```



When n = 0, y[n] = 1, x[n] = 0, which means there exists an output while the input is 0.

So, the system $y[n] = x[n] + x[n+1]$ is not causal.

(c)

For these problems, you will be given a system and a property that the system does not satisfy, but must discover for yourself an input or pair of input signals to base your argument upon. Again, create MATLAB vectors to represent the inputs and outputs of the system and generate appropriate plots with these vectors. Use your plots to make a clear and concise argument about why the system does not satisfy the specified property.

(c). The system $y[n] = \log(x[n])$ is not stable.

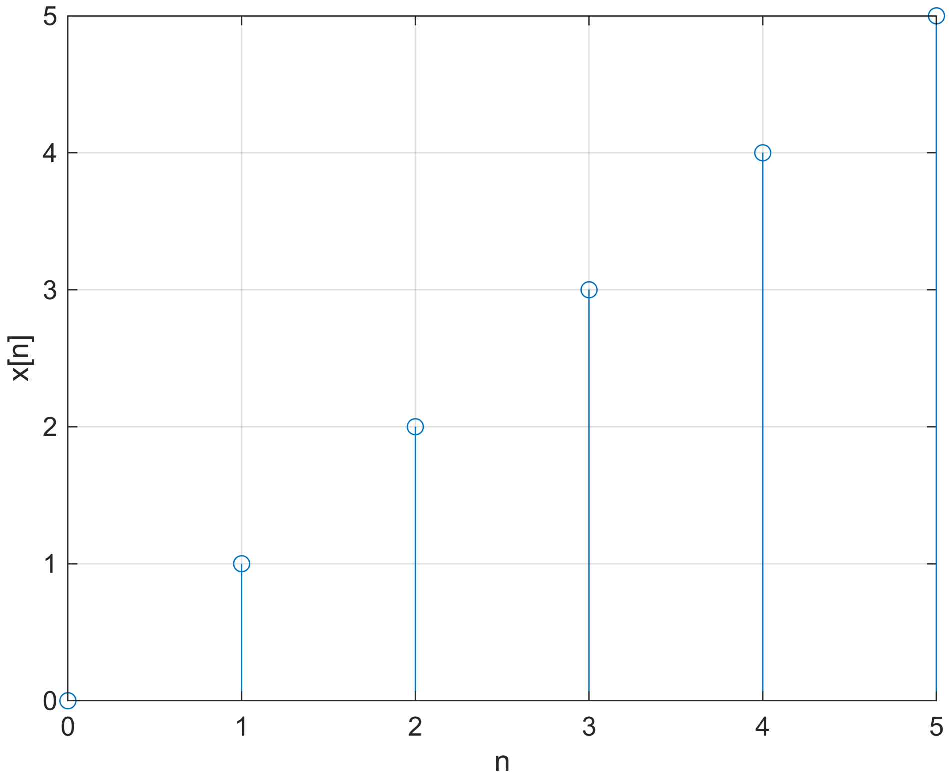
Initialize.

```
clear; clc; close all;
```

Assume $x[n] = n(n \geq 0)$, create vector x plot it.

```
n = 0:5;
x = n;
figure;
stem(n,x);
grid on;
xlabel('n');
```

```
xticks(n);
ylabel('x[n]');
yticks(0:5);
```

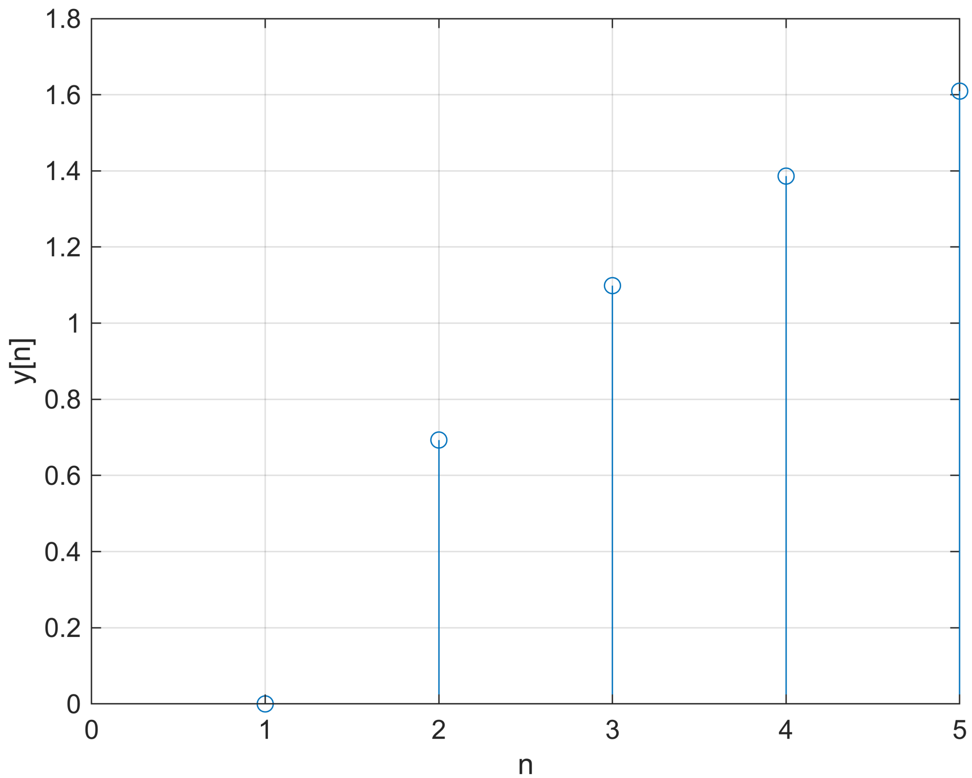


Calculate y[n].

```
y = log(x);
```

Plot the y[n].

```
figure;
stem(n,y);
grid on;
axis([0,5,ylim]);
xlabel('n');
xticks(n);
ylabel('y[n]');
```



Since y[n] is:

```
y
```

```
y = 1×6
       -Inf         0    0.6931    1.0986    1.3863    1.6094
```

From the above table, we know y[0] = $-\infty$.

According to the definition, the system is not stable.

(d)

(d). The system given in Part (a) is not invertible.

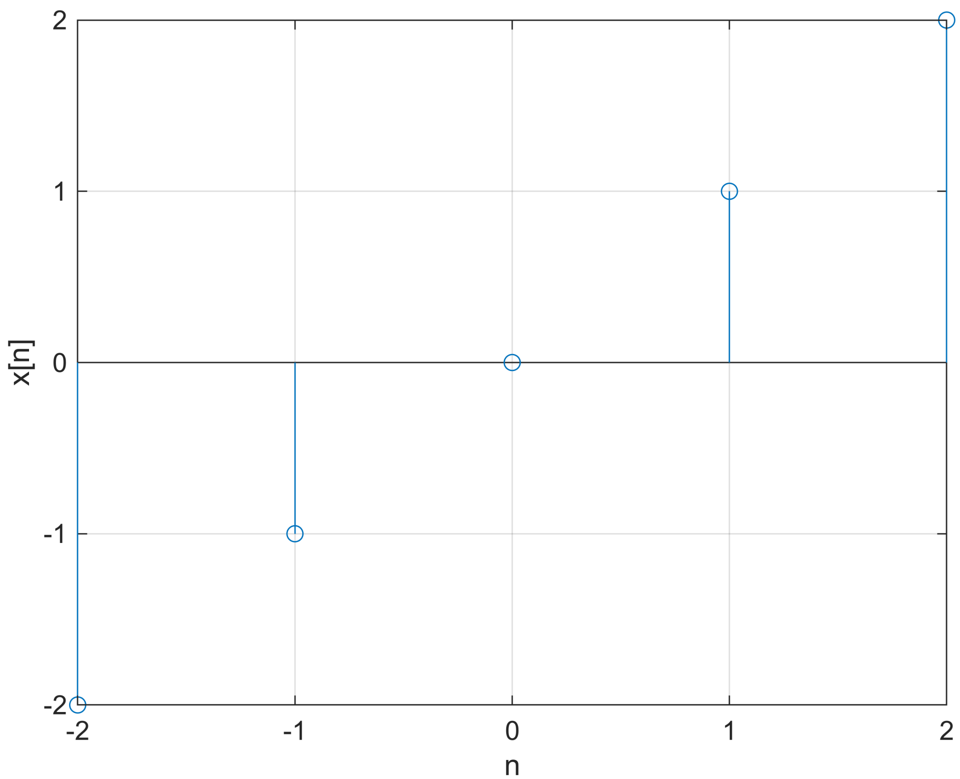
Initialize.

```
clear; clc; close all;
```

Assume $x[n] = n$, create vector x and plot it.

```
n = -2:2;
x = n;
figure;
stem(n,x);
grid on;
```

```
xlabel('n');
xticks(n);
ylabel('x[n]');
yticks(-2:2);
```

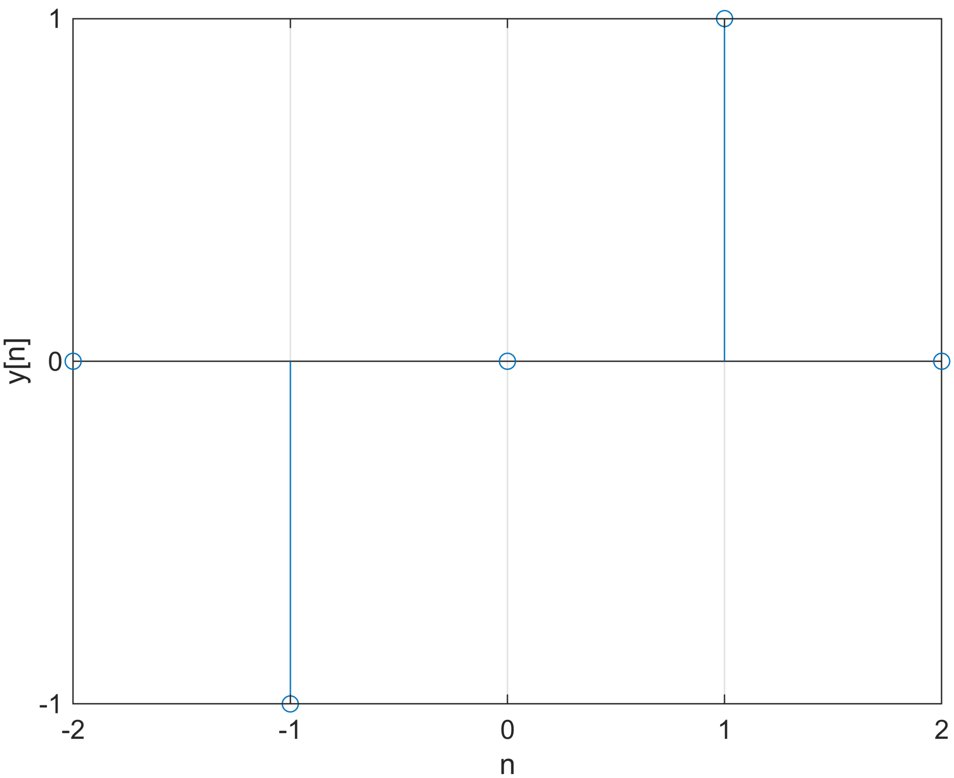


Calculate y[n].

```
y = sin((pi/2)*x);
```

Plot the y[n].

```
figure;
stem(n,y);
grid on;
xlabel('n');
xticks(n);
ylabel('y[n]');
yticks([-1,0,1]);
```



From the above figure, we know $x[0] \neq x[2]$ but $y[0] = y[2]$.

According to the definition, the system is not invertible.

1.5

(a)

(a). Write a function **y=diffeqn(a,x,yn1)** which computes the output $y[n]$ of the causal system determined by Eq. (1.6). The input vector **x** contains $x[n]$ for $0 \leq n \leq N-1$ and **yn1** supplies the value of $y[-1]$. The output vector **y** contains $y[n]$ for $0 \leq n \leq N-1$. The first line of your M-file should read

```
function y = diffeqn(a,x,yn1)
```

Hint: Note that $y[-1]$ is necessary for computing $y[0]$, which is the first step of the autoregression. Use a **for** loop in your M-file to compute $y[n]$ for successively larger values of n, starting with $n = 0$.

function is written at the end

(b)

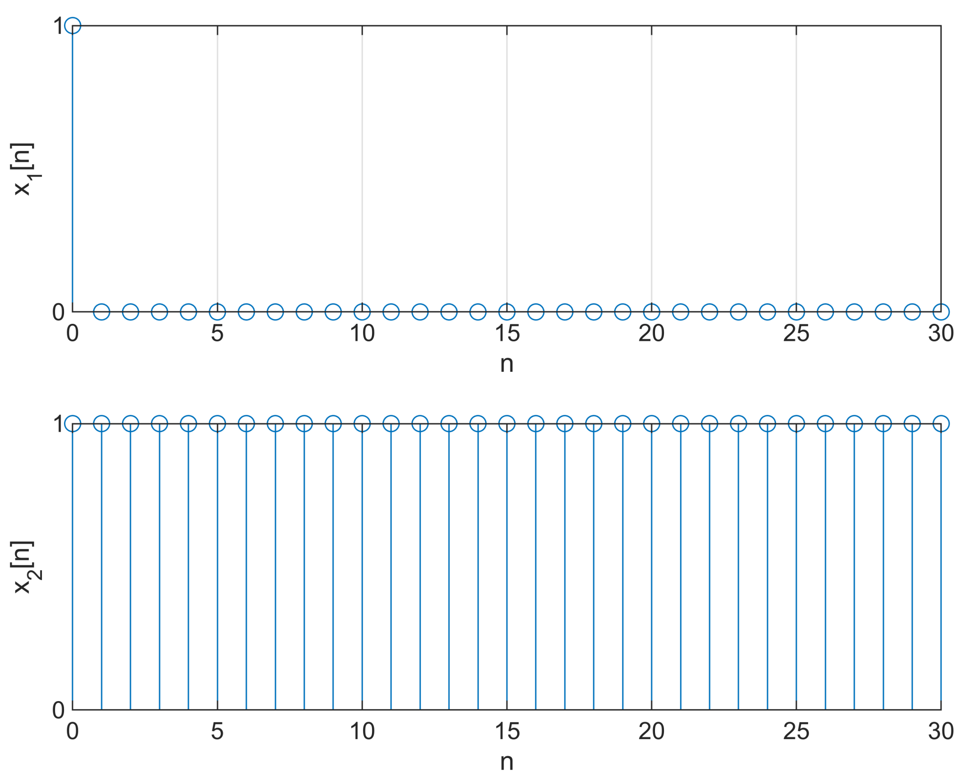
(b). Assume that $a = 1$, $y[-1] = 0$, and that we are only interested in the output over the interval $0 \leq n \leq 30$. Use your function to compute the response due to $x_1[n] = \delta[n]$ and $x_2[n] = u[n]$, the unit impulse and unit step, respectively. Plot each response using **stem**.

Initialize.

```
clear; clc; close all;
```

Create two vectors x_1 and x_2 and plot them.

```
n = 0:30;
x1 = unitimpulse(n);
x2 = unitstep(n);
figure;
subplot(2,1,1),stem(n,x1);
grid on;
xlabel('n');
ylabel('x_1[n]');
yticks([0,1]);
subplot(2,1,2),stem(n,x2);
grid on;
xlabel('n');
ylabel('x_2[n]');
yticks([0,1]);
```

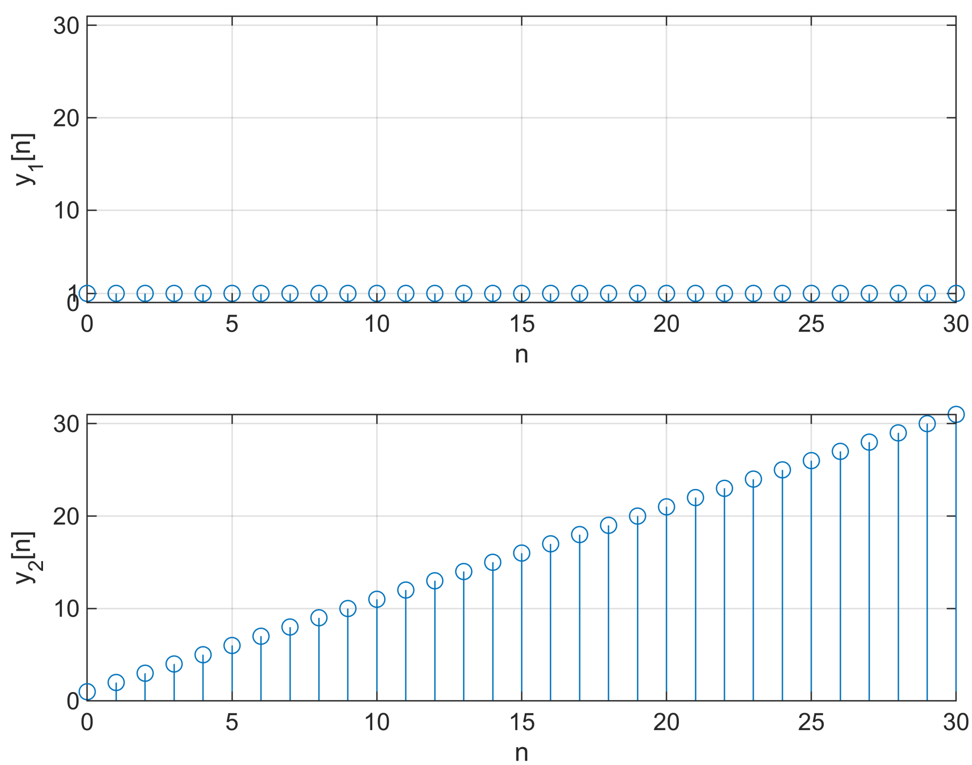


Calculate y_1 and y_2.

```
y1 = diffeqn(1,x1,0);
y2 = diffeqn(1,x2,0);
```

Plot and compare y_1 and y_2 .

```
figure;
subplot(2,1,1),stem(n,y1);
grid on;
axis([xlim,0,31]);
xlabel('n');
ylabel('y_1[n]');
yticks([0,1,10,20,30]);
subplot(2,1,2),stem(n,y2);
grid on;
xlabel('n');
ylabel('y_2[n]');
```



The answer is the graph above.

(c)

(c). Assume again that $a = 1$, but that $y[-1] = -1$. Use your function to compute $y[n]$ over $0 \le n \le 30$ when the inputs are $x_1[n] = u[n]$ and $x_2[n] = 2\,u[n]$. Define the outputs produced by the two signals to be $y_1[n]$ and $y_2[n]$, respectively. Use **stem** to display both outputs. Use **stem** to plot $(2\,y_1[n] - y_2[n])$. Given that Eq. (1.6) is a linear difference equation, why isn't this difference identically zero?

Initialize.

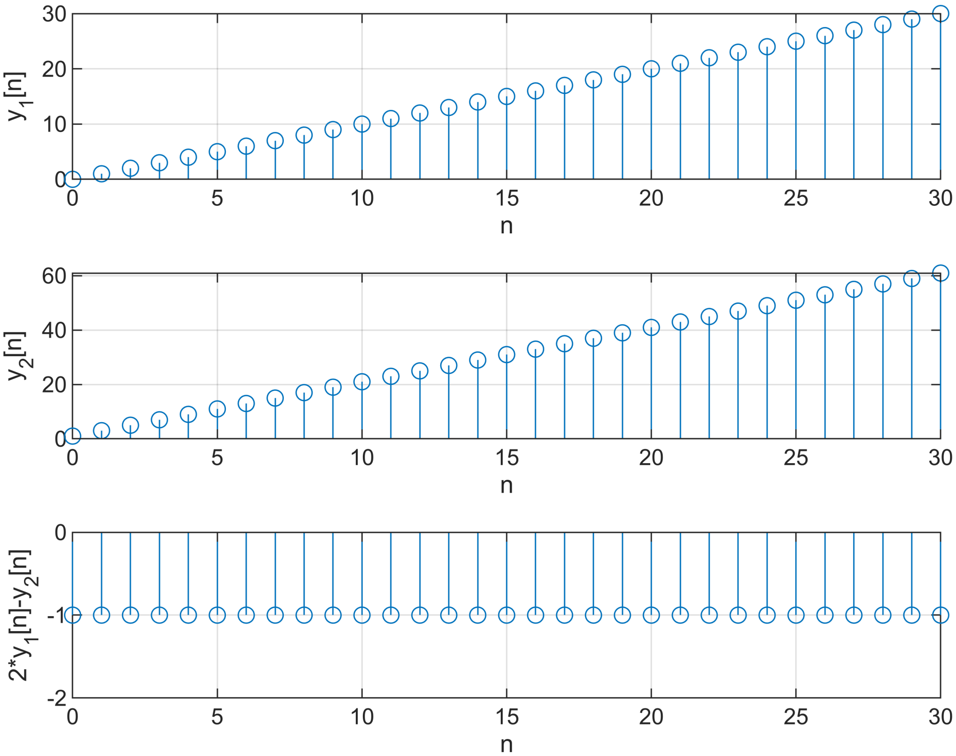
```
clear; clc; close all;
```

Create two vectors $x_1 = u[n]$ and $x_2 = 2 * u[n]$ and plot them.

```
a = 1; yn1 = -1; n = 0:30;
x1 = unitstep(n);
x2 = 2 * unitstep(n);
```

Calculate $y_1[n] = a * y[-1] + x_1[n]$ and $y_2[n] = a * y[-1] + x_2[n]$, and plot them.

```
y1 = diffeqn(a, x1, yn1);
y2 = diffeqn(a, x2, yn1);
figure;
tiledlayout(3,1);
nexttile;stem(n, y1);
grid on;xlabel('n');ylabel('y_1[n]');
nexttile;stem(n, y2);
grid on;xlabel('n');ylabel('y_2[n]');
nexttile;stem(n, 2*y1 - y2);
axis([0 30 -2 0]);
grid on;xlabel('n');ylabel('2*y_1[n]-y_2[n]');
```



Since it's linear, $2*y_1[n]-y_2[n]=a*y[-1]+(2*x_1[n]-x_2[n])$ where $(2*x_1[n]-x_2[n])=(2*u_1[n]-u_2[n])=0$.

Then $2*y_1[n]-y_2[n]=a*y[-1]$, that is $2*y_1[n]-y_2[n]=-1$.

So, even if Eq. (1.6) is a linear difference equation, this difference can be not identically zero.

Functions

Unit step function

```
function y = unitstep (x)
    y = double(x>=0);
end
```

Unit impulse function

```
function y = unitimpulse (x)
    y = double(x==0);
end
```

Function 'diffeqn' in question 1.5

```
function y = diffeqn (a,x,yn1)
    if length(x) <= 0
        error 'length(x) should larger than 0';
    end
```

```
    y = zeros(1, length(x));
    y(1) = a*yn1+x(1);
    for i = 2:length(x)
        y(i) = a*y(i-1)+x(i);
    end
end
```

Expeience

涂峻绫：

Through Matlab work, I have a preliminary understanding of Matlab simulation tools in the signal and system of the application of the discipline. Specifically, I practice to use MATLAB to represent impulse function, step function and discrete-time signals， and use matlab to verify discrete-time systems' properties. Use simple linear constant-coefficient difference equations (such as the first-order autoregression equation) to describe discrete-time systems.

During this lab, I also find some mistakes which are easy to make when coding. It's a good expericence to discover them and to avoid them in the future.

欧阳安男：

Through Matlab work, I have a preliminary understanding of Matlab simulation tools in the signal and system of the application of the discipline.

For each aspects in introduction, the score of myself evaluation is

1. Use MATLAB to represent impulse function, step function. (100)

2. Use MATLAB to represent discrete-time signals. (100)

3. Explore the effect of simple transformations of the independent variable, such as delaying the signal or reversing its time axis. (100)

4. Use matlab to verify discrete-time systems' properties such as linearity, time invariance, stability, causality, and invertibility. (100)

5. Use simple linear constant-coefficient difference equations (such as the first-order autoregression equation) to describe discrete-time systems. (100)

Score

涂峻绫（100），欧阳安男（100）