## 2.10

10)   $x[n] = \left\{ 1, 3, 2, -1 \right\}$

   $h[n] = 2(0.8)^n$     ,    $0 \le n \le 6$

a)   $y[3] = ?$

   $y$

$h[n] = \begin{bmatrix} 2 & 1.6 & 1.28 & 1.024 & 0.8192 & 0.65536 & 0.524288 \end{bmatrix}$

$h[-k] = \begin{bmatrix} 0.52488 & 0.65536 & 0.8192 & 1.024 & 1.28 & 1.6 & 2 \end{bmatrix}$

$h[3-k] =$

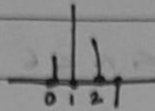| $x[n]$ | $\cdots$ | | 0 | 0 | 0 | 0 | 1 | 3 | 2 | -1 |
|--------|----------|---|---|---|---|---|---|---|---|----|
| $h[3-k]$ | | | | | | | 1.024 | 1.28 | 1.6 | 2 | |

   $y[3] = x[n]$

$$y[3] = \sum_{-\infty}^{\infty} x[k] \, h[3-k]$$

$y[3] = 1 \times 1.024 + 3 \times 1.28 + 2 \times 1.6 - 1 \times 2$

$y[3] = 6.064$

6)

x[k]
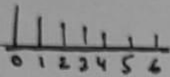

0 1 2

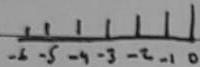h[k]


0 1 2 3 4 5 6

h[-k]


-6 -5 -4 -3 -2 -1 0

h[3-k]


-3 -2 -1 0 1 2 3

y[3]



y[3]
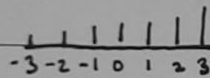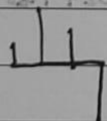
# 2.17

A discrete-time system is described by the following difference equation

**y[n] = 1.15y[n − 1] − 1.5y[n − 2] + 0.7y[n − 3] − 0.25y[n − 4] + 0.18x[n] + 0.1x[n − 1] + 0.3x[n − 2] + 0.1x[n − 3] + 0.18x[n − 4]**
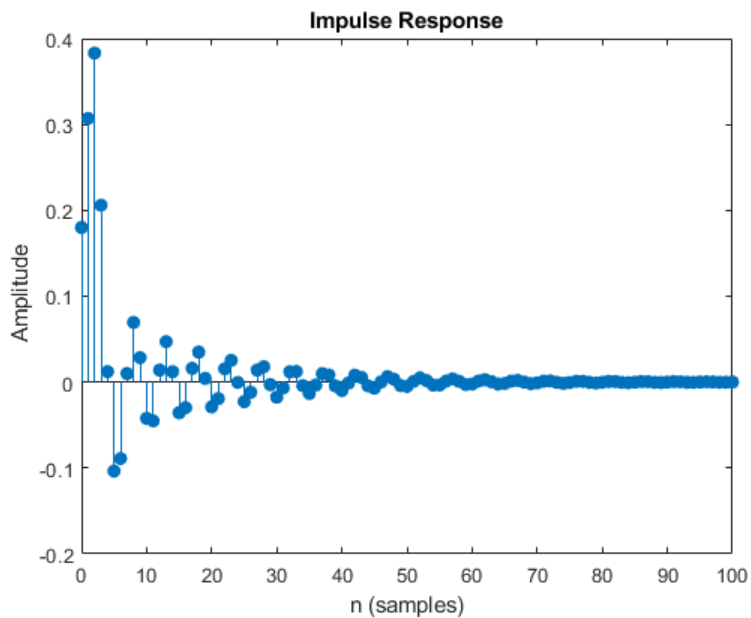
with zero initial conditions.

```
a = [1 -1.15 1.5 -0.7 0.25];
b = [0.18 0.1 0.3 0.1 0.18];
n = [0:100];
```

(a) Compute and plot the impulse response h[n], 0 ≤ n ≤ 100 using the function

**h=impz(b,a,N)**.
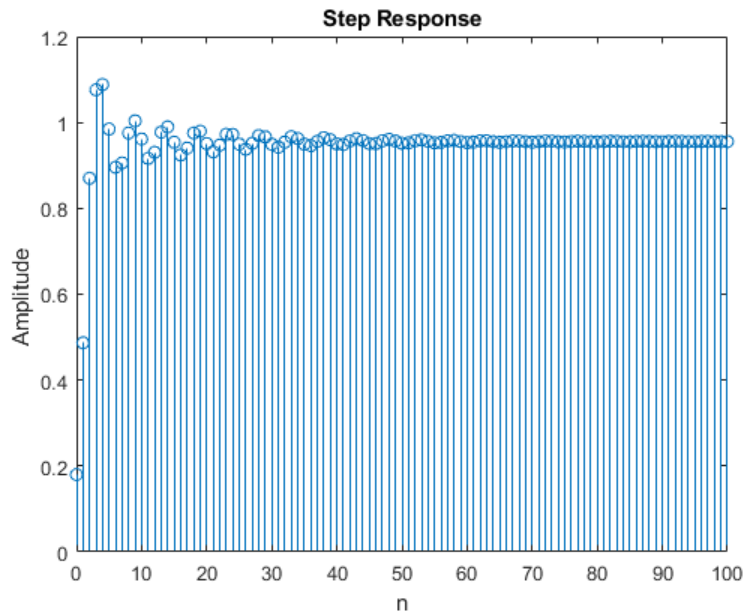
```
h = impz(b,a,length(n));
impz(b,a,length(n))
```



(b) Compute and plot the output y[n], if x[n] = u[n], 0 ≤ n ≤ 100 using the function

**y=filter(b,a,x)**.
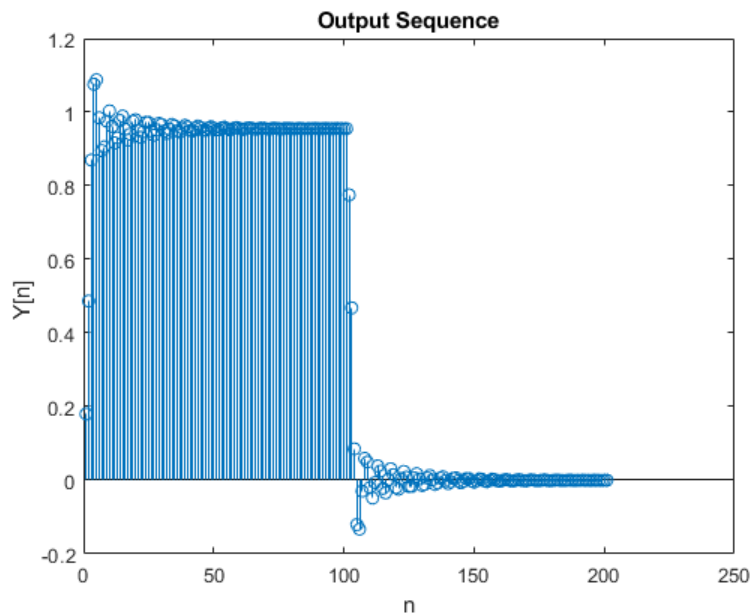
```
y = filter(b,a,ones(1,length(n)));
stem(n,y)
```

```
title('Step Response') ; xlabel('n') ; ylabel('Amplitude ')
```



Step Response

(c) Compute and plot the output y[n], if x[n] = u[n], 0 ≤ n ≤ 100 using the function
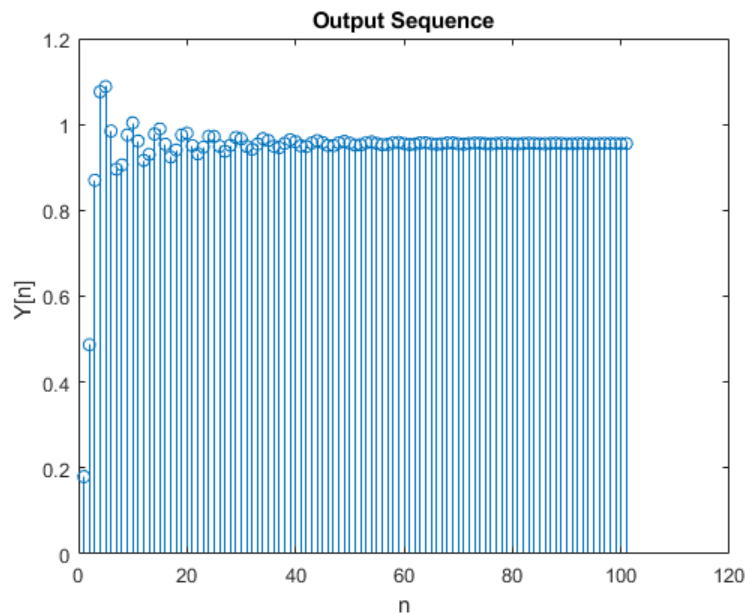
**y=conv(h,x).**

```
y = conv(h,ones(1,length(n)));
stem(y)
title('Output Sequence') ; xlabel('n') ; ylabel('Y[n] ')
```



Output Sequence

(d) Compute and plot the output y[n], if x[n] = u[n], 0 ≤ n ≤ 100 using the function

**y=filter(h,1,x)**

```
y = filter(h,1,ones(1,length(n)));
stem(y)
title('Output Sequence') ; xlabel('n') ; ylabel('Y[n] ')
```



Part A gives the Impulse Response of the System

Part B gives the Step Response of the System

Part C by convolving gives both the Step and Impulse Response of the system

Part D gives the Zero State Response of the System, this mean the response of the system when initial conditions are set to Zero which is ame as Step Response of the System.
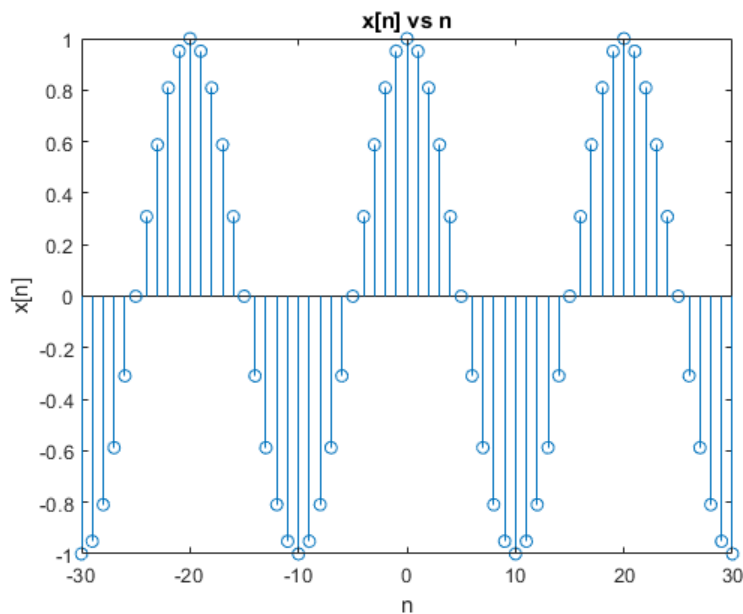
# 2.22

A downsampler system is defined in (2.24). Consider the sequence x[n] = cos(0.1πn)

for −30 ≤ n ≤ 30. Using the stem function plot

(a) x[n] versus n.

(b) A down sampled signal y[n] for M = 5.

(c) A down sampled signal y[n] for M = 20.

(d) How does the downsampled signal appear? Compressed or expanded.

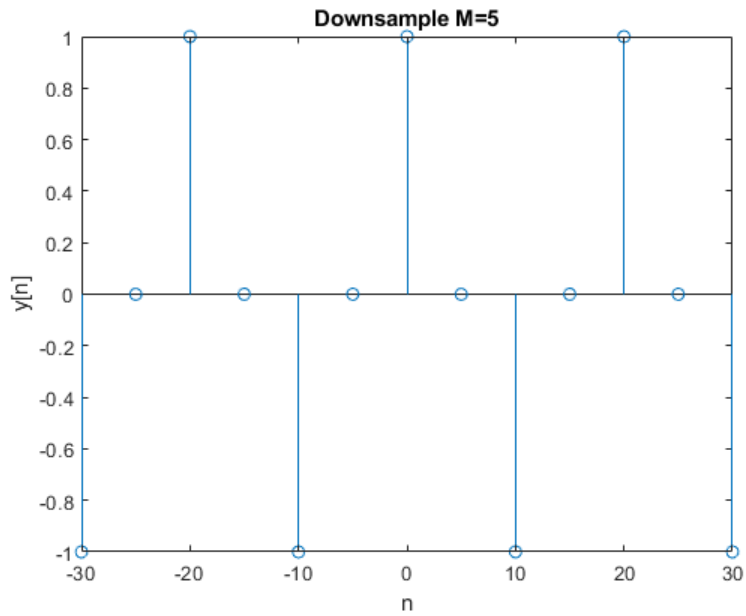$$y[n] = H\{x[n]\} = x[nM]  (2.24)$$

**a)**

```
n = [-30:30];
xn = cos(0.1*pi*n);

stem(n,xn)
title('x[n] vs n'); xlabel('n') ; ylabel('x[n]');
```



**b)**

```
n5d = downsample(n,5);
xn5d = downsample(xn,5);

stem(n5d,xn5d)
```
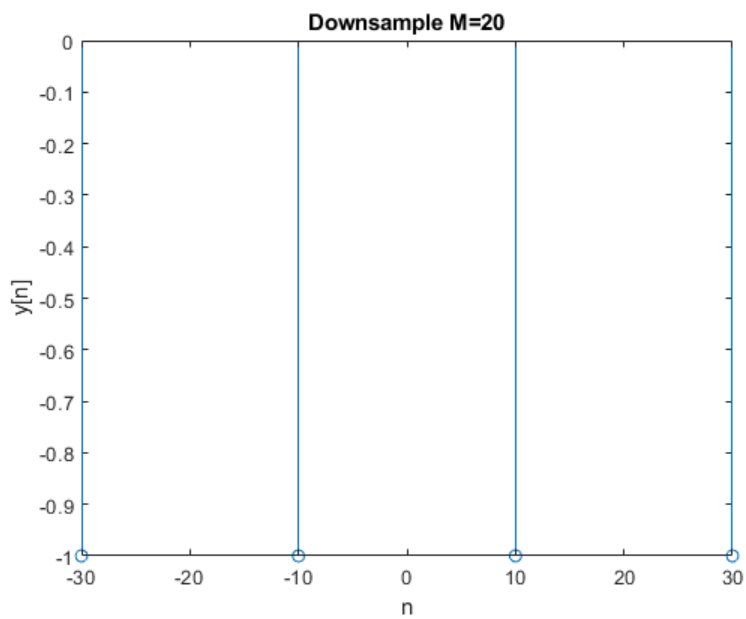
```
title('Downsample M=5'); xlabel('n') ; ylabel('y[n]');
```

**Downsample M=5**



c)

```
n20d = downsample(n,20);
xn20d = downsample(xn,20);

stem(n20d,xn20d)
title('Downsample M=20'); xlabel('n') ; ylabel('y[n]');
```

**Downsample M=20**



d) **Compressed**

## 2.23

23)

   a)    $y[n] = x[-n]$

$$\mathcal{H}\{a_1 x_1[n] + a_2 x_2[-n]\} = a_1 \mathcal{H}\{x_1[n]\} + a_2 \mathcal{H}\{x_2[-n]\}$$

      ∴ System is linear

Time invariant  No
Causal       No

$$y[n] = x[n+1] - x[n-1]$$

Stable     Yes

b)  $y[n] = \log(|x[n]|)$

     Linear  No
     Time Invariant  Yes
     Causal  Yes

     Not BIBO stable

     ∴ Stable  No

c)  $y[n] = x[n] - x[n-1]$

     Linear   Yes
     $T_I$     Yes
     Causal    Yes
     Stable    Yes

d)  $y[n] = roun\{x[n]\}$

     Linear   No
     $T_I$     Yes
     Causal    Yes
     Stable    Yes

## 2.27

27)

$x[n] = a^n u[n]$     $h[n] = b^n u[n]$

$a = 1/4$     $u[n] \triangleq \begin{cases} 1 & n \geq 0 \\ 0 & n < 0 \end{cases}$

$b = 1/3$

$x[n] = \{16 \quad 1 \quad 0.25 \quad 0.0625 \quad 0.0156 \quad \cdots \}$

$x[n] = \{\underset{\uparrow}{1} \quad 0.25 \quad 0.0625 \quad 0.0156 \quad \cdots \}$

$h[n] = \{\underset{\uparrow}{1} \quad 1/3 \quad 1/9 \quad 1/27 \quad \cdots \}$

$h(-k) = \{\cdots \quad 1/27 \quad 1/9 \quad 1/3 \quad \underset{\uparrow}{1} \}$

| $x[n]$ | 0 | 0 | 0 | 1 | 0.25 | 0.0625 | 0.0156 |
|---|---|---|---|---|---|---|---|
| $h[1-k]$ | $1/81$ | $1/27$ | $1/9$ | $1/3$ | 1 | 0 | 0 |
| $h[2-k]$ | . | $1/81$ | $1/27$ | $1/9$ | $1/3$ | 1 | |
| $h[3-k]$ | . | . | $1/81$ | $1/27$ | $1/9$ | $1/3$ | 1 |

$y[n] = [0.25 + 1/3 \quad , \quad 1/3 \times 0.25 + 1/9 \quad , \quad 1/3 \times 0.0625 + 1/9 \times 0.25$
$\qquad + 1/27 \quad , \quad \cdots ]$

$y[n] = 0.4643 \quad 0.1548 \quad 0.0172 \quad \cdots \cdots$
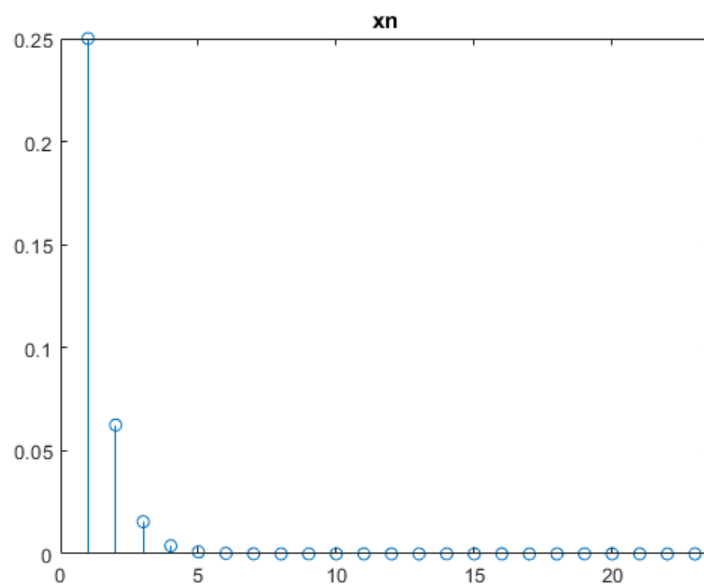
```
n = 1:100;
un = ones(1,length(n));

an = (1/4) * ones(1,length(n));
an = an.^n;
xn = an.*un;

stem(xn)
title('xn')

xlim([0.0 23.6])
ylim([0.000 0.250])
```
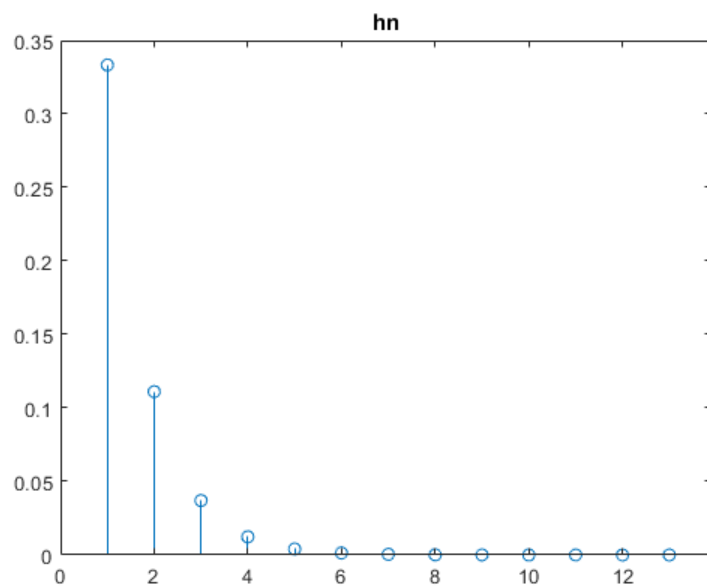


xn

```
bn = (1/3) * ones(1,length(n));
bn = bn.^n;
hn = bn.*un;

stem(hn)
title('hn')

xlim([0.0 13.9])
ylim([0.000 0.350])
```
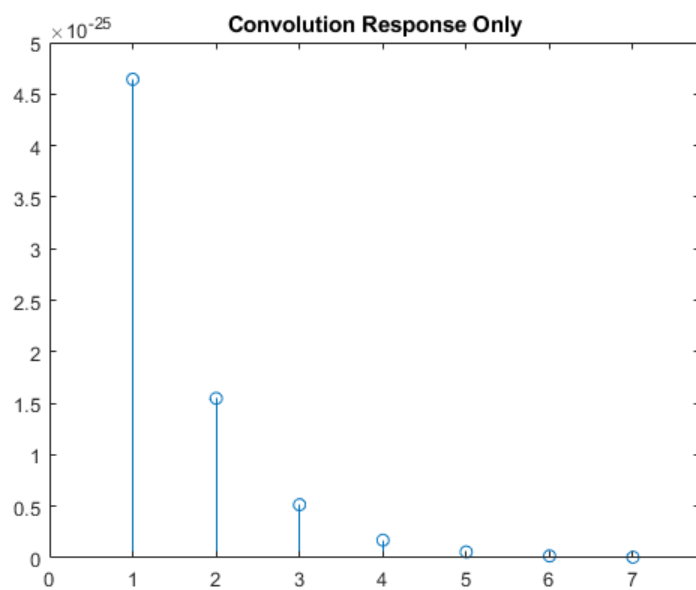
## hn



```matlab
yn = conv(xn,hn,'same');

stem(yn)
title('Convolution Response Only')
xlim([0.00 7.81])
```
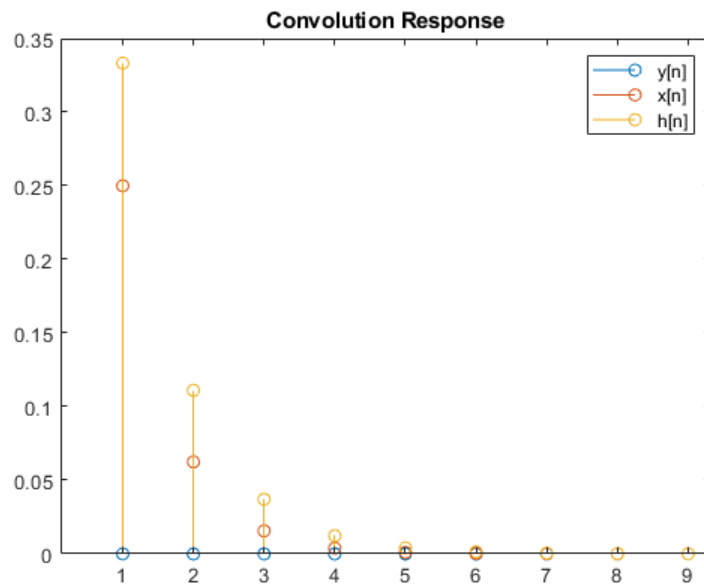
## Convolution Response Only



```matlab
stem(yn)
hold on
stem(xn)
```

```
stem(hn)
title('Convolution Response')

legend('y[n]','x[n]','h[n]')
xlim([0.12 9.33])
ylim([0.000 0.350])
hold off
```



## 2.31

Consider the system y[n] = y[n − 1] + y[n − 2] + x[n], y[−1] = y[−2] = 0.

(a) Compute and plot the impulse response, for 0 ≤ n ≤ 100, using function filter.

(b) Can you draw any conclusions about the stability of this system from the results in (a)?

(c) Determine the output y[n], if the input is x[n] = an, −∞ < n < ∞, and comment upon the result.

**a)**

```
a = [1 -1 -1];
b = [1];
n = [1;100];
```
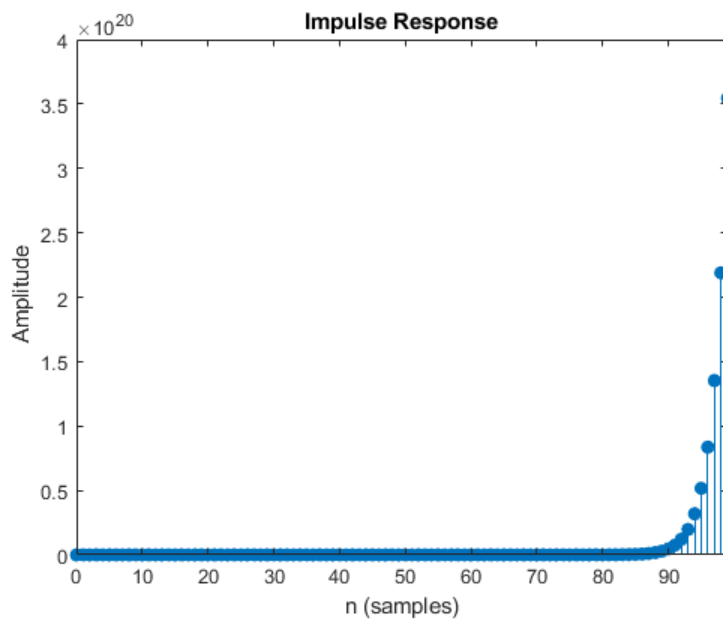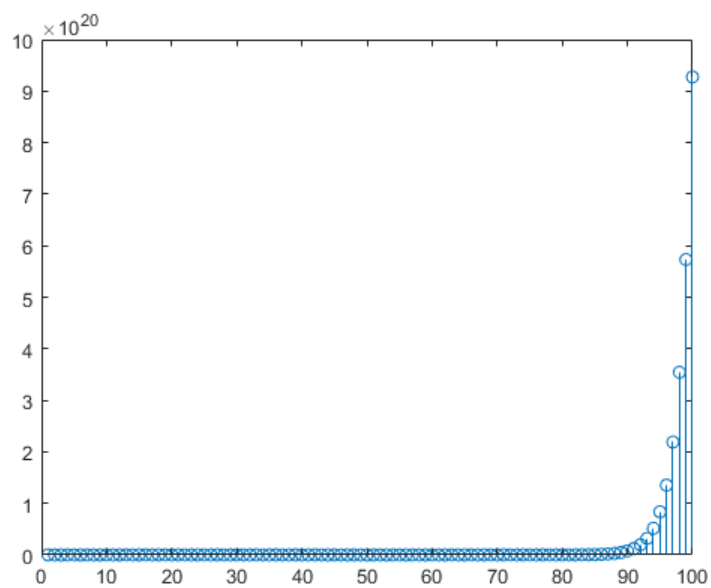
```
figure;
impz(b,a,100)
```
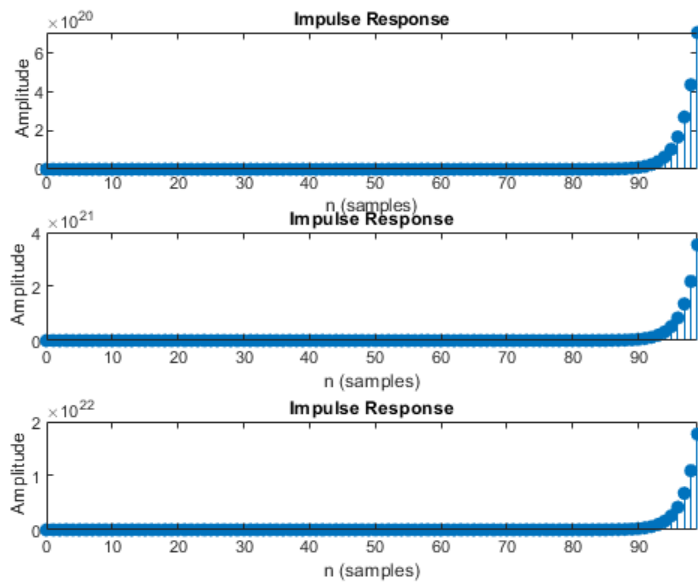

Impulse Response

```
y = filter(b,a,ones(1,100));
figure;
stem(y)
```



**b) The Function is not decaying and continues and hence is not stable.**

**c)**

```
c  = [2];
d = [10];
e = [50];

figure;
subplot(3,1,1)
impz(c,a,100)
subplot(3,1,2)
impz(d,a,100)
subplot(3,1,3)
impz(e,a,100)
```



The shape of impulse response will remain the same, however. the amplitude now increases at a greater exponential scale.