Signal Processing E/15/202

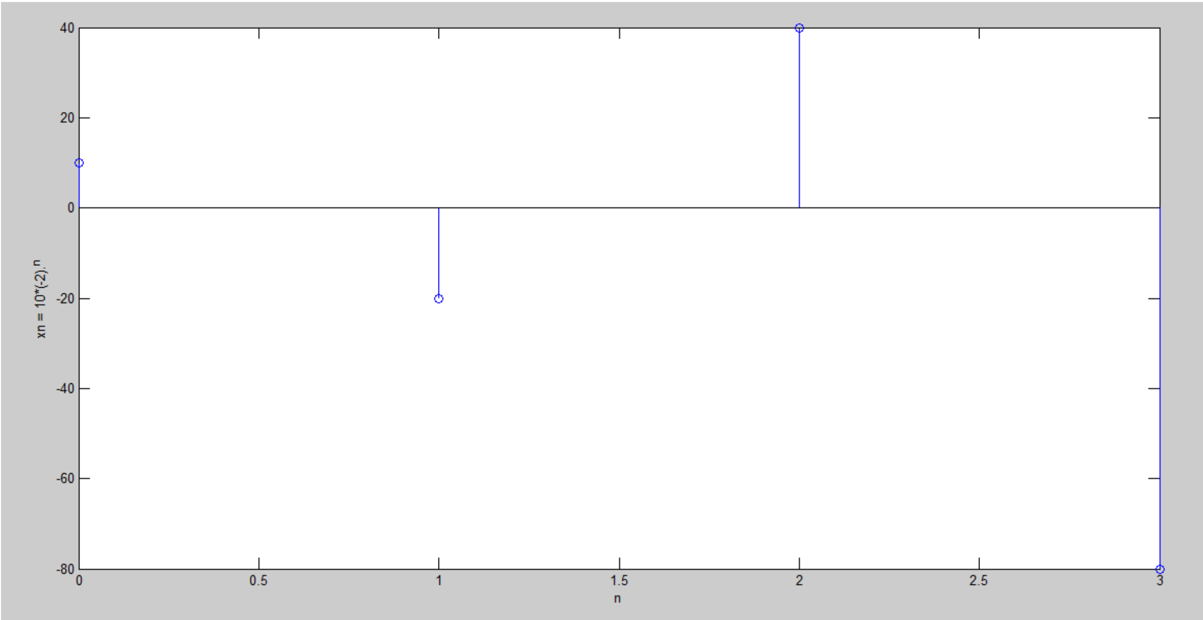
Laboratory on Discrete Time Signals

1) a) i) $\beta < -1$

Consider $\beta = -2$

Then $x[n] = 10(-2)^n$, $n >= 0$

```
n = 0:1:3;
stem(n,10*(-2).^n)
xlabel('n');
ylabel('xn = 10*(-2).^n');
```

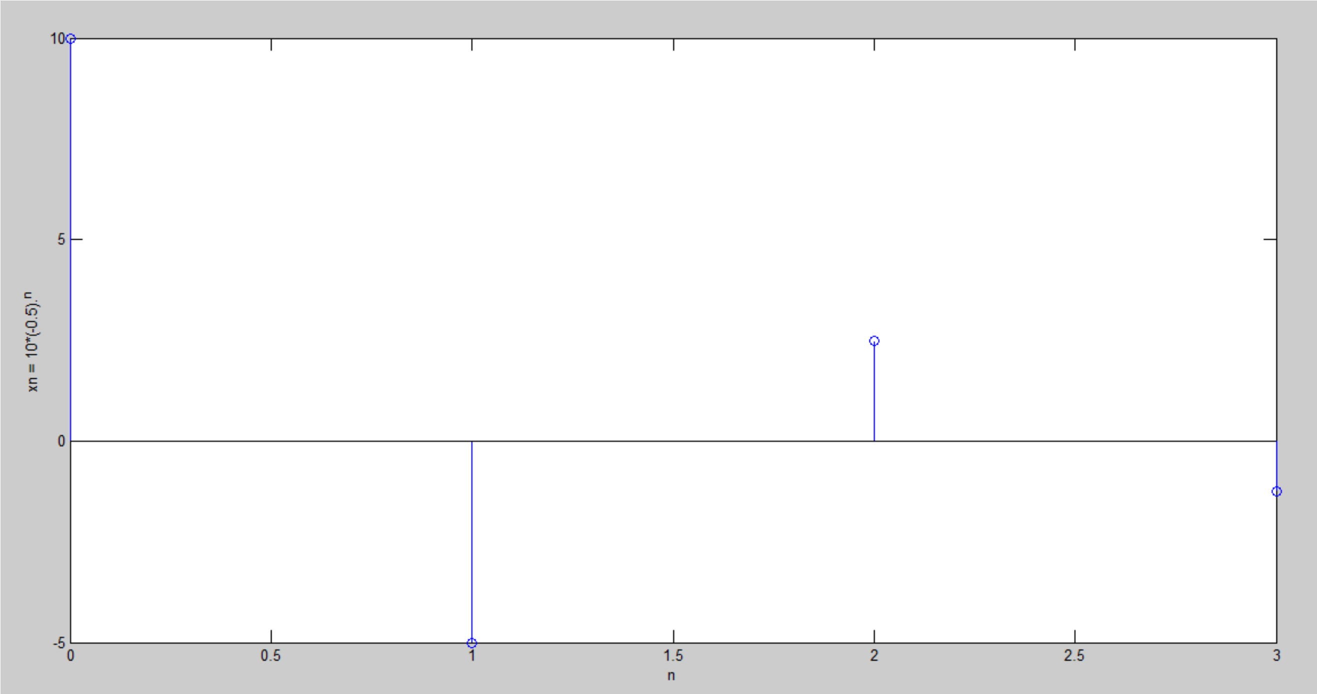


ii) $-1 < \beta < 0$

Consider $\beta = -0.5$

Then $x[n] = 10(-0.5)^n$, $n >= 0$

```
n = 0:1:3;
stem(n,10*(-0.5).^n)
xlabel('n');
ylabel('xn = 10*(-0.5).^n');
```

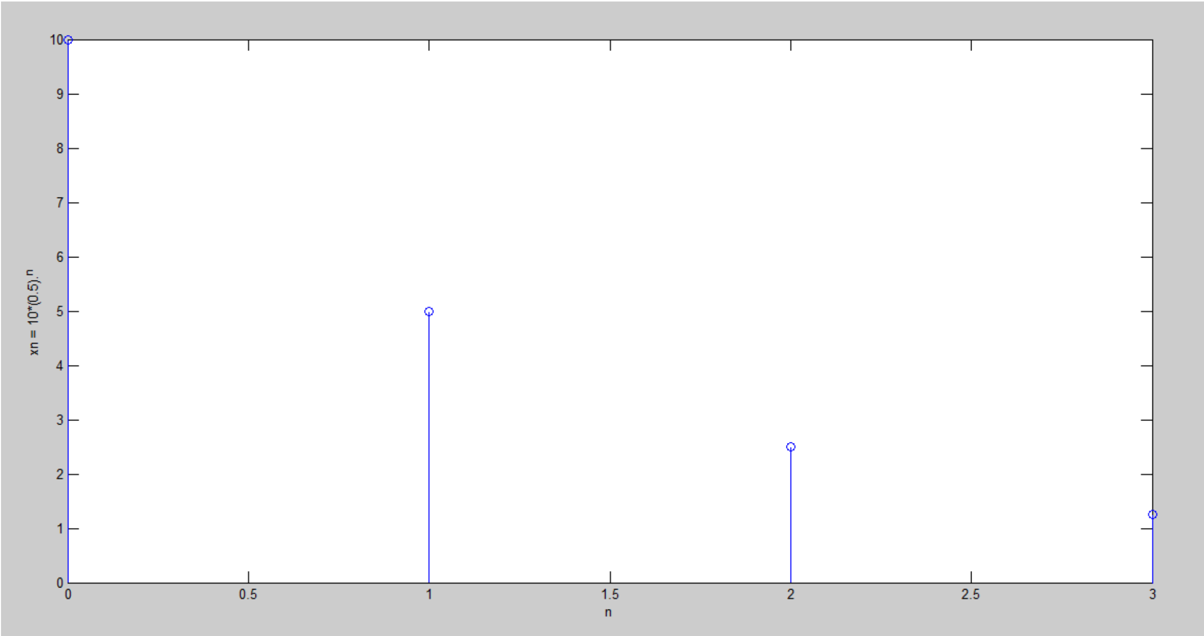


iii) $0 < \beta < 1$

Consider $\beta = 0.5$

Then $x[n] = 10(0.5)^n$, $n >= 0$

```
n = 0:1:3;
stem(n,10*(0.5).^n)
xlabel('n');
ylabel('xn = 10*(0.5).^n');
```

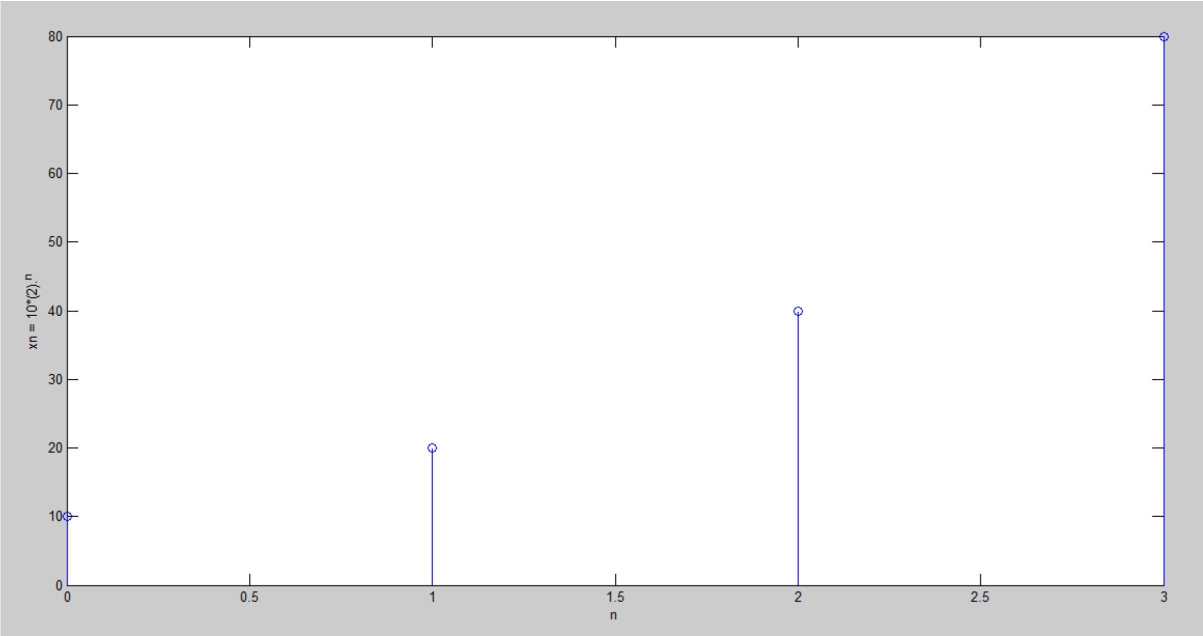


iv) $\beta > 1$

Consider $\beta = 2$

Then $x[n] = 10(2)^n$, $n >= 0$

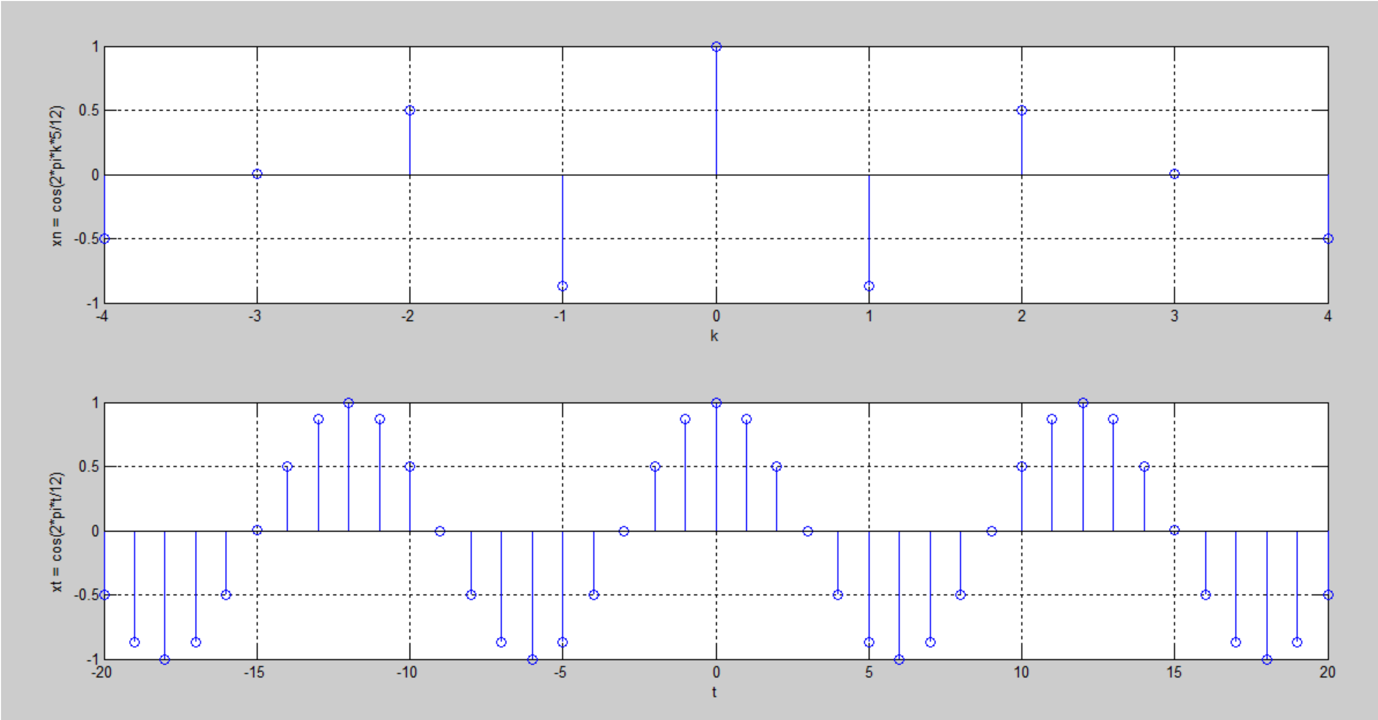
```
n = 0:1:3;
stem(n,10*(2).^n)
xlabel('n');
ylabel('xn = 10*(2).^n');
```



b) i)

```
function xt = sample1(t)
      xt = cos(2*pi*t/12);
end

function xn = sample2(k)
    xn = cos(2*pi*k*5/12);
end


t = -20:1:20;
xt = sample1(t);

k = -4:1:4;
xn = sample2(k);

subplot(2,1,1)
stem(k,xn)
xlabel('k');
ylabel('xn = cos(2*pi*k*5/12)');grid
subplot(2,1,2)
stem(t,xt)
xlabel('t');
```

```
ylabel('xt = cos(2*pi*t/12)');grid
```



Consider x[t],

When t = 0, $x[t] = \cos\left(\frac{2\pi t}{12}\right) = 1$

When t = 12, $x[t] = \cos\left(\frac{2\pi t}{12}\right) = 1$

Therefore theoretically fundamental frequency of x[t] is 12s

Therefore, n = kT = 12

Then k = 12/5 = 2.5

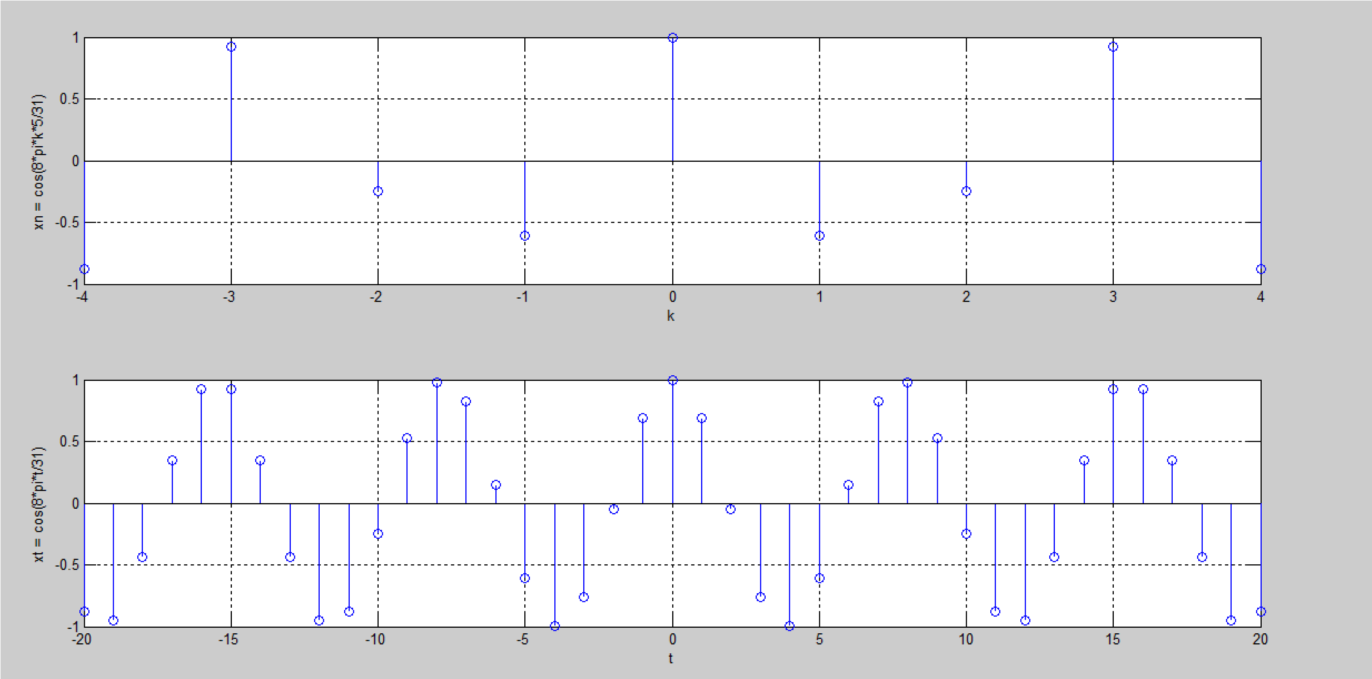
Fundamental frequency of x[n] is 2.5

But the observed fundamental frequency of x[n] is not equal to the theoretical value because the k is taken as an integer value. Sampling is done at integer k. Since the fundamental frequency of x[t] is an integer the observed value of x[t] is equal to the theoretical value.

ii)

```
function xt = sample1(t)
      xt = cos(8*pi*t/31);
end

function xn = sample2(k)
    xn = cos(8*pi*k*5/31);
end
t = -20:1:20;
xt = sample1(t);
k = -4:1:4;
xn = sample2(k);
subplot(2,1,1)
stem(k,xn)
xlabel('k');
ylabel('xn = cos(8*pi*k*5/31)');grid
```

```
subplot(2,1,2)
stem(t,xt)
xlabel('t');
ylabel('xt = cos(8*pi*t/31)');grid
```



Consider x[t],

When t = 0, $x[t] = \cos\left(\frac{8\pi t}{31}\right) = 1$

When t = 31/4, $x[t] = \cos\left(\frac{8\pi t}{31}\right) = 1$

Therefore theoretically fundamental frequency of x[t] is (31/4)s

Therefore, n = kT = 31/4

Then k = 31/20 = 1.55

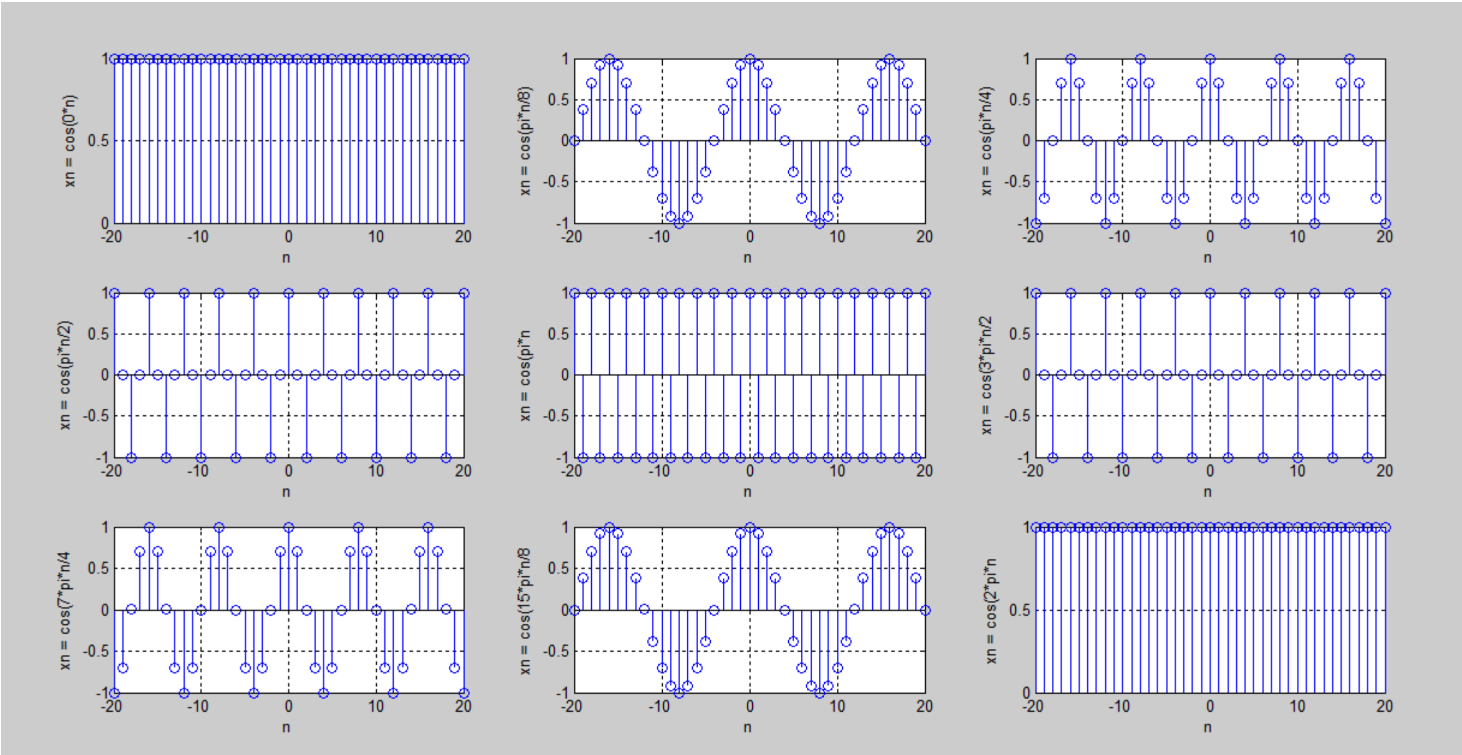
Fundamental frequency of x[n] is 1.55

Here, both the observed fundamental frequencies of x[t] and x[n] are not equal to the theoretical value because both of the theoretical values are not integers.

c)

```
n  = -20:1:20;
subplot(3,3,1)
xn = sample1(n);
stem(n, cos(0*n))
xlabel('n');
ylabel('xn = cos(0*n)');grid

subplot(3,3,2)
xn = sample1(n);
stem(n, cos(pi*n/8))
xlabel('n');
```

```
ylabel('xn = cos(pi*n/8)');grid

subplot(3,3,3)
xn = sample1(n);
stem(n, cos(pi*n/4))
xlabel('n');
ylabel('xn = cos(pi*n/4)');grid

subplot(3,3,4)
xn = sample1(n);
stem(n, cos(pi*n/2))
xlabel('n');
ylabel('xn = cos(pi*n/2)');grid

subplot(3,3,5)
subplot(3,3,5)
xn = sample1(n);
stem(n, cos(pi*n))
xlabel('n');
ylabel('xn = cos(pi*n');grid

subplot(3,3,6)
xn = sample1(n);
stem(n, cos(3*pi*n/2))
xlabel('n');
ylabel('xn = cos(3*pi*n/2');grid

subplot(3,3,7)
xn = sample1(n);
stem(n, cos(7*pi*n/4))
xlabel('n');
ylabel('xn = cos(7*pi*n/4');grid

subplot(3,3,8)
xn = sample1(n);
stem(n, cos(15*pi*n/8))
xlabel('n');
ylabel('xn = cos(15*pi*n/8');grid

subplot(3,3,9)
xn = sample1(n);
stem(n, cos(2*pi*n))
xlabel('n');
ylabel('xn = cos(2*pi*n');grid
```



d) When the discrete frequency increases we will not be able to clearly identify the sine wave shape in the signals. Because it will start to show only 1 or -1, no any other mediated values. But this will happen only to a mid-value. Then again it start to show the identifiable sine wave form.

2) a)

```
function x = myconv(xn,hn)
        ylen = length(xn)+length(hn);
        xlen = ylen+length(hn)-1;
        newxn = zeros(1,xlen);

        for r = 1:length(xn)
                newxn(r+length(hn)-1) = xn(r);
        end

        for n = 1:ylen-1
                e = 0;
                newhn = zeros(xlen,1);
                for f = length(hn):-1:1
                        newhn(n+e,1) = hn(f);
                        e = e + 1;
                end
                x(n) = newxn * newhn;

        end
end
```

b)

```
function y = sm1(n)
        for k = 1:length(n)
                if n(k) >= 0
                        y(k) = (0.5.^n(k))*1;
                else
```

```
                y(k) = 0;
            end
        end
    end

    function y =sm2(n)
        for k = 1:length(n)
            if n(k) >= 0
                y(k) = 1;
            else
                y(k) = 0;
            end
        end
    end

subplot(2,2,1)
n = 0:1:10;
xn = sm1(n);
stem(n,xn)
xlabel('n');
ylabel('xn = 0.5^n * u(n)');
subplot(2,2,2)
hn = sm2(n);
stem(n,hn)
xlabel('n');
ylabel('hn = u(n)');
subplot(2,2,3)
yn = myconv(xn,hn);
length(yn)
ans =

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n = 0:20;
stem(n,yn)
xlabel('n');
ylabel('yn = xn*hn');
```
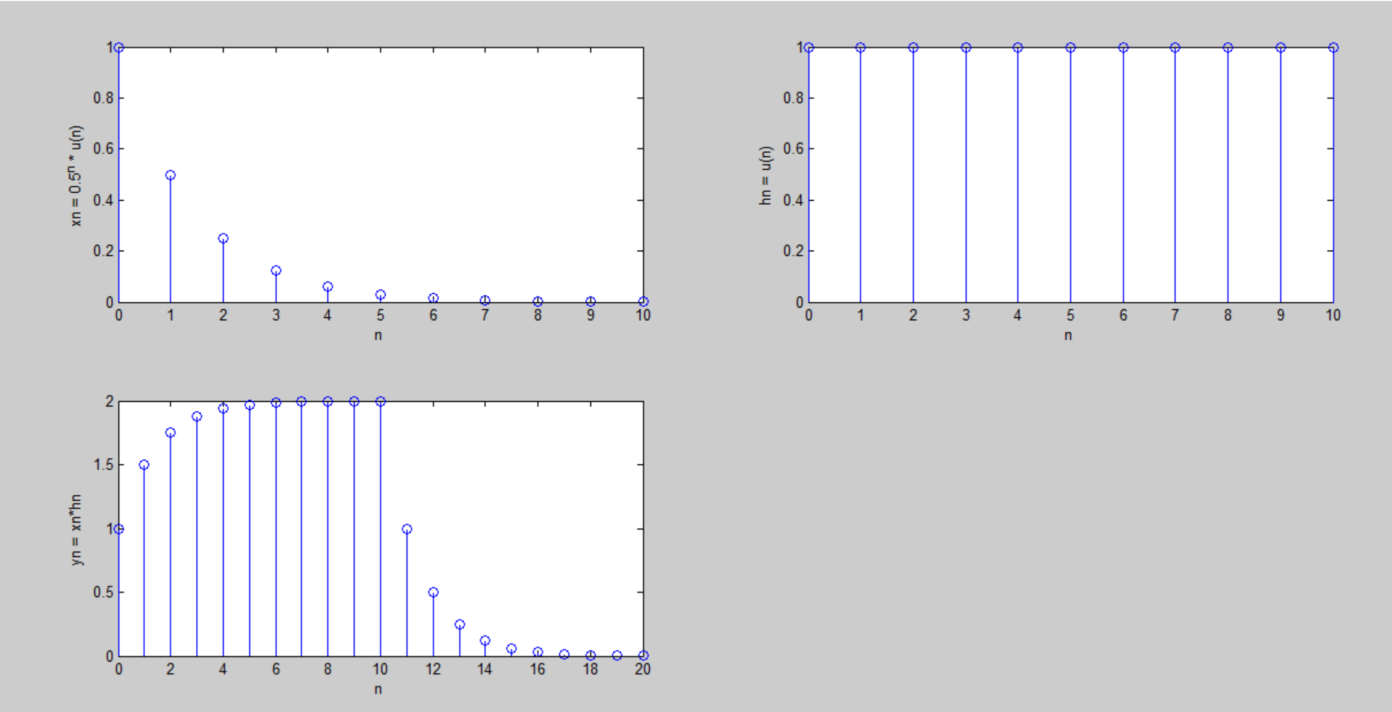



c) iii)

```
xn = [1,1,1,1,1,0,0,0,0,0,0,0,0,0,0];
hn = [2,4,8,16,32,64,0,0,0,0,0,0,0,0,0];
myconv(xn,hn)

ans =

  Columns 1 through 23

     2      6     14     30     62    124    120    112     96     64      0      0
0      0      0      0      0      0      0      0      0      0      0

  Columns 24 through 29

     0      0      0      0      0      0


conv(xn,hn)

ans =

  Columns 1 through 23

     2      6     14     30     62    124    120    112     96     64      0      0
0      0      0      0      0      0      0      0      0      0      0

  Columns 24 through 29

     0      0      0      0      0      0
```

iv) A linear transformation

3) a) **i)** n = number of months (a positive integer)

$x[n] = P(1.01)^n$

$y[n] = x[n]$

$B = P(1.01)^n$

```
function B = lti1(P,n)
      for x = 1:length(n)
            B(x) = P.*(1.01).^n(x);
      end
end
```

ii) n = number of months (a positive integer)

x[n] = M amount of money monthly

y[n] = x[0]/2 + x[1]/2 + x[2]/2 + … = $\sum_{k=0}^{n} 0.5x[k]$

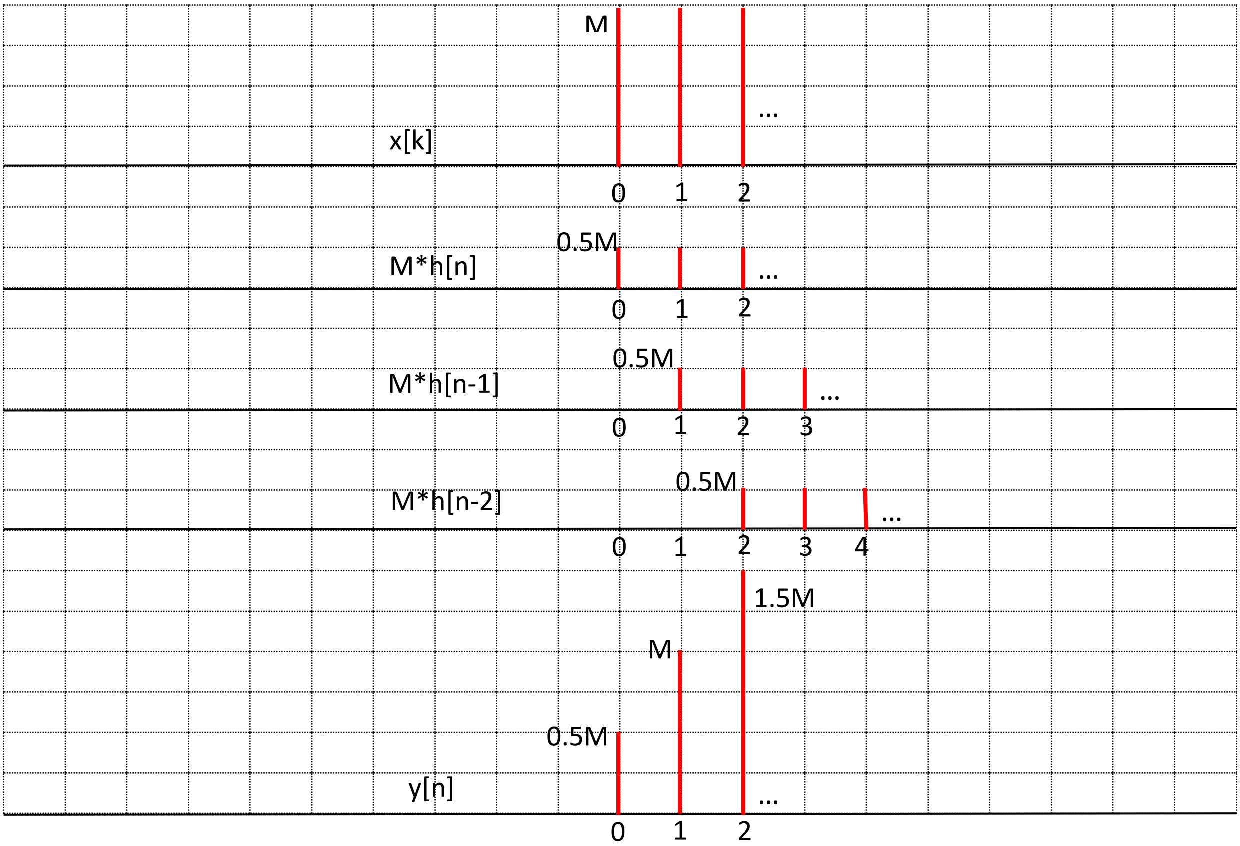
```
function yn = lti2(M,n)
      sumSave = 0;
      for x = 1:length(n)
            sumSave = sumSave + 0.5*M;
            yn(x) = sumSave;
      end
end
```

b) **i)** Here x[n] = y[n], Therefore according to convolution,

h[n] = [1]

ii)

$$y[n] = \sum_{k=0}^{n} x[k]h[n-k]$$



Therefore,

h[n] = [0.5,0.5,0.5,…]

c) **i)** FIR

ii) IIR