Digital Signal Processing Laboratory

EXPERIMENT-7

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PROBLEM STATEMENT -01

Consider the below square pulse

$x(t) = 1 \quad 0 \leq t \leq T$

$= 0 \quad$ otherwise

Part-1 Sample the signal using sampling frequency fs

Compute DTFT using formulae.

a) Fix fs and vary T. Plot the magnitude and phase spectrum or three different values of T. Compute the bandwidth. Comment on the result.

b) Fix T and vary fs. Plot the magnitude and phase spectrum for three different values of fs. Compute the Bandwidth. Comment on the result

Ans:

a) Fs = 0.5Hz

```
% 1-a
clc;
t= 0:100;
T =10:10:40; %varying the T

fs =0.5 ; %sampled frequency
Ts = 1/fs;

%% creating input array for given different values of T
x =zeros(length(T),length(t));
x = insig(t,T);

%% sampling the signal as per given rate

samplx =zeros(length(T),length(t)); % defing sampled arrays
for i=1:length(T)
    t1 = 1:Ts:T(i)-Ts;
    n=length(t1);
    for j= 1:n
        samplx(i,floor(t1(j))) = x(i,floor(t1(j)));
    end
end
%%

syms w
% Calculating DTFT
```

```
%X(e^jω) = ∑ x[n]*e(-jωn)
for i = 1:length(T)
  t1 = 1:Ts:T(i)-Ts;
  H(i) = sum(samplx(i).*exp(-1i*w.*t1));
end

% function for creating the continous time signals based on T given
function y = insig(t,T)
    y =zeros(length(T),length(t));
    for i=1:length(T)
        for j=1:length(t)
             if(t(j)<=T(i))
             y(i,j) =1;
             else
            y(i,j)=0;
              end
        end
    end
end
```

- For the plotting of graphs, I plotted each graph individually and copy pasted on the report. Since the code is very big I did not kept it here.
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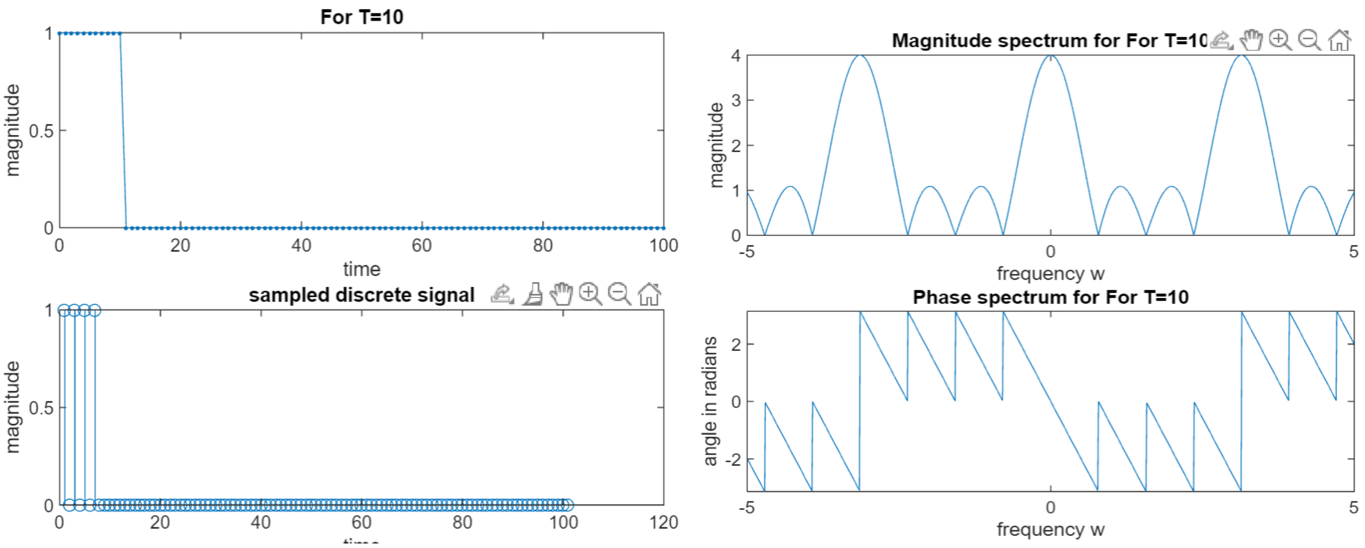
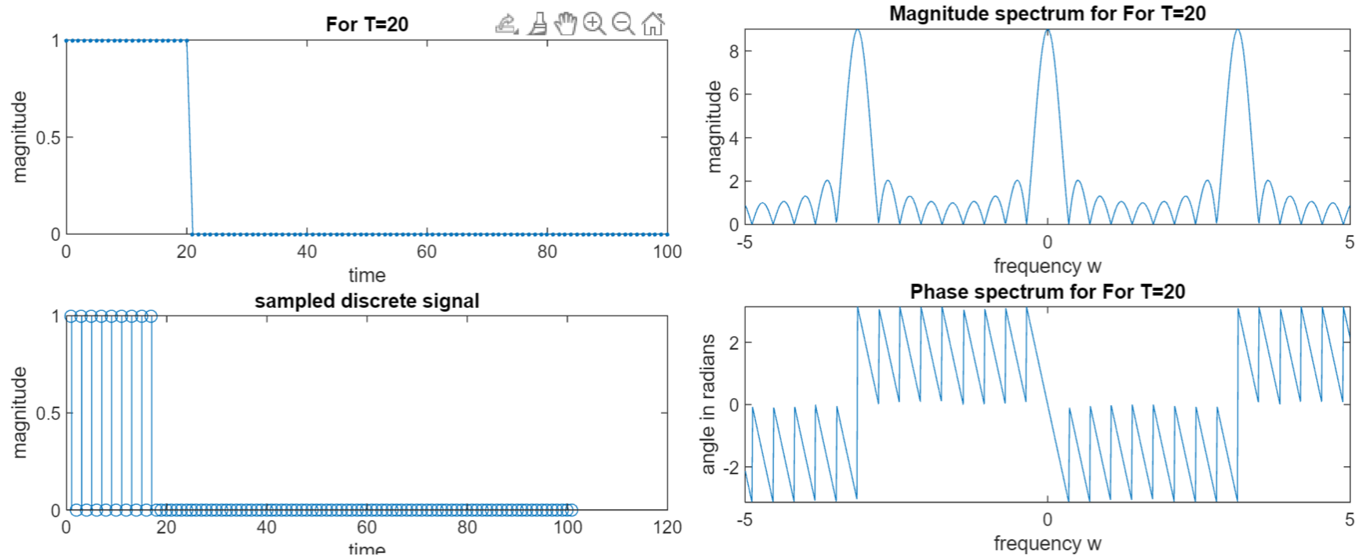
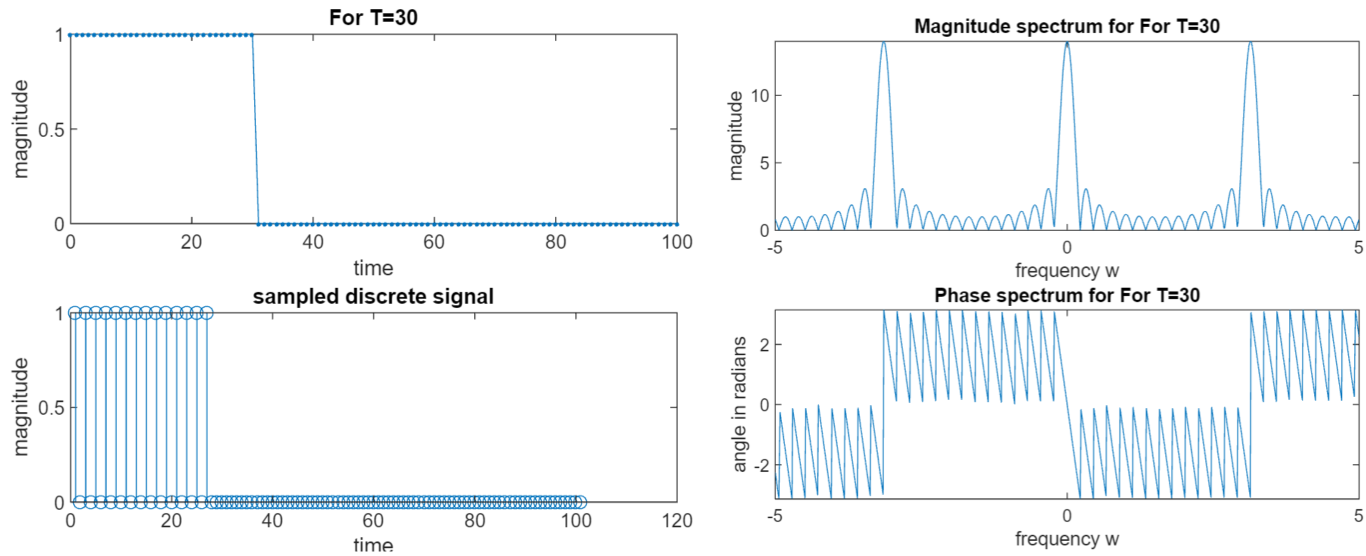
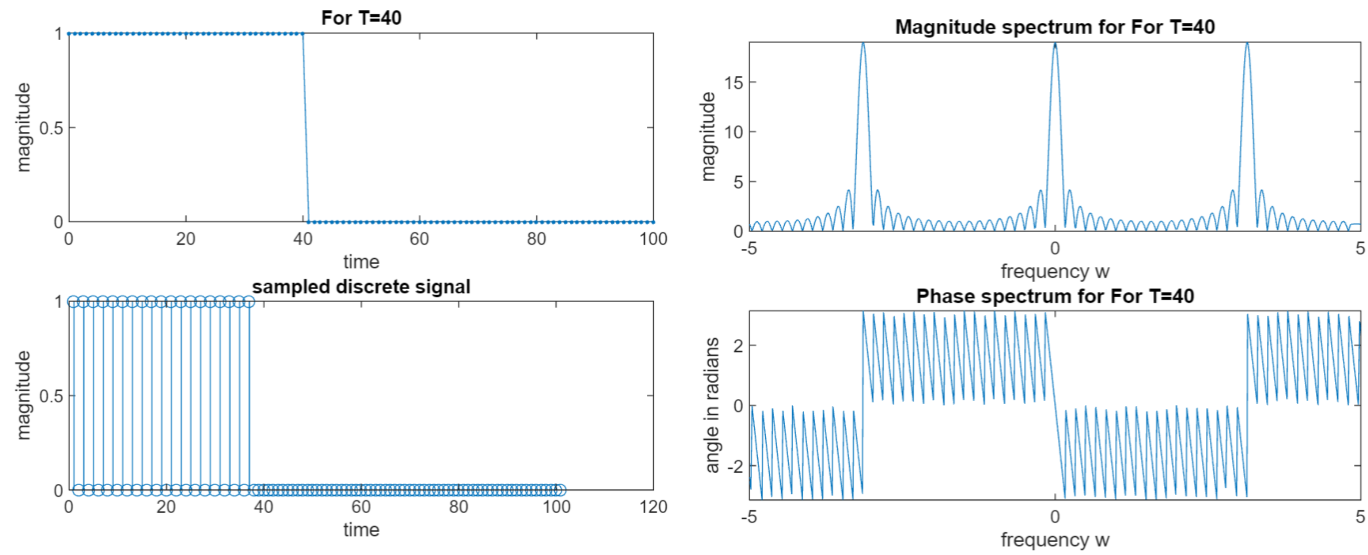



For T=20
magnitude
time
sampled discrete signal
magnitude
time
Magnitude spectrum for For T=20
magnitude
frequency w
Phase spectrum for For T=20
angle in radians
frequency w

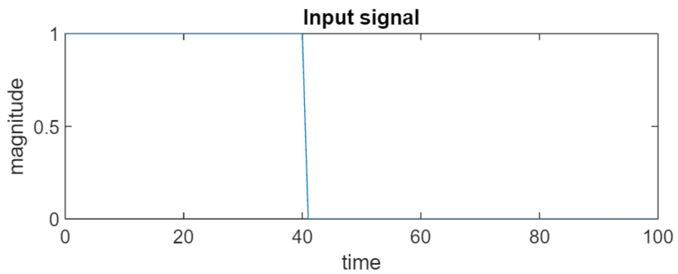

For T=30
magnitude
time
sampled discrete signal
magnitude
time
Magnitude spectrum for For T=30
magnitude
frequency w
Phase spectrum for For T=30
angle in radians
frequency w

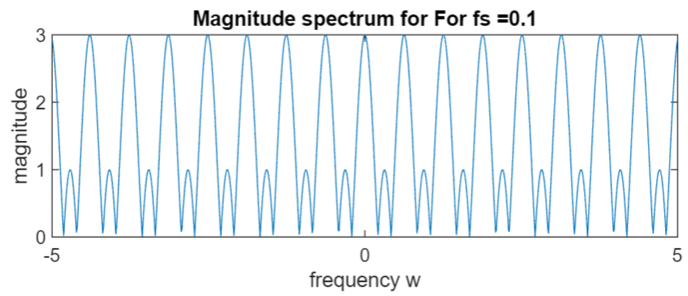

For T=40
magnitude
time
sampled discrete signal
magnitude
time
Magnitude spectrum for For T=40
magnitude
frequency w
Phase spectrum for For T=40
angle in radians
frequency w

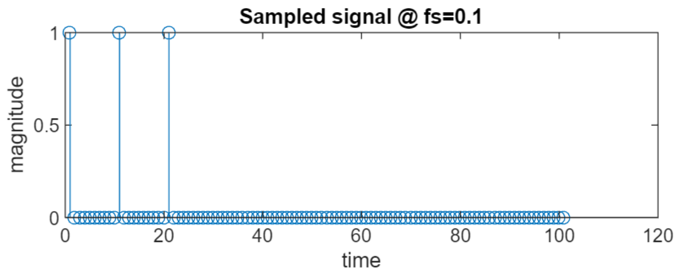
b) T =40

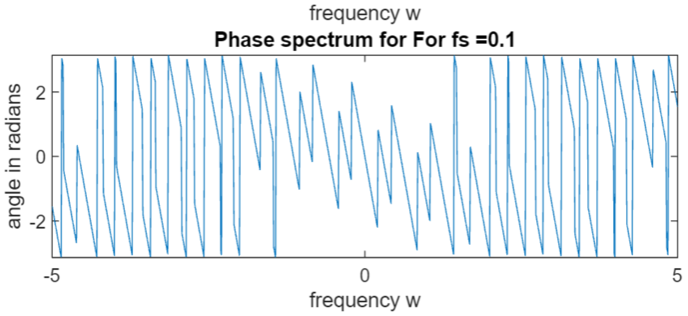
```
% 1-b
clc;
t= 0:100;
T =40;
fs = 0.1:0.1:0.4 ; %varying sampling frequency
Ts = 1./fs;

%% creating input array for given T
x =zeros(length(T),length(t));
x = insig(t,T,Ts);

%% sampling the signal as per given different rates

samplx =zeros(length(Ts),length(t)); % defining the sampled arrays

for i=1:length(Ts)
    t1 = 1:Ts(i):T-Ts(i);
    n=length(t1);
    for j= 1:n
        samplx(i,floor(t1(j))) = x(i,floor(t1(j)));
    end
end
%%

syms w
% Calculating DTFT
%X(e^jω) = ∑ 𝑥[𝑛]*e(-j𝜔𝑛)

for i = 1:length(Ts)
  t1 = 1:Ts(i):T-Ts(i);
  H(i) = sum(samplx(i).*exp(-1i*w.*t1));
end
```

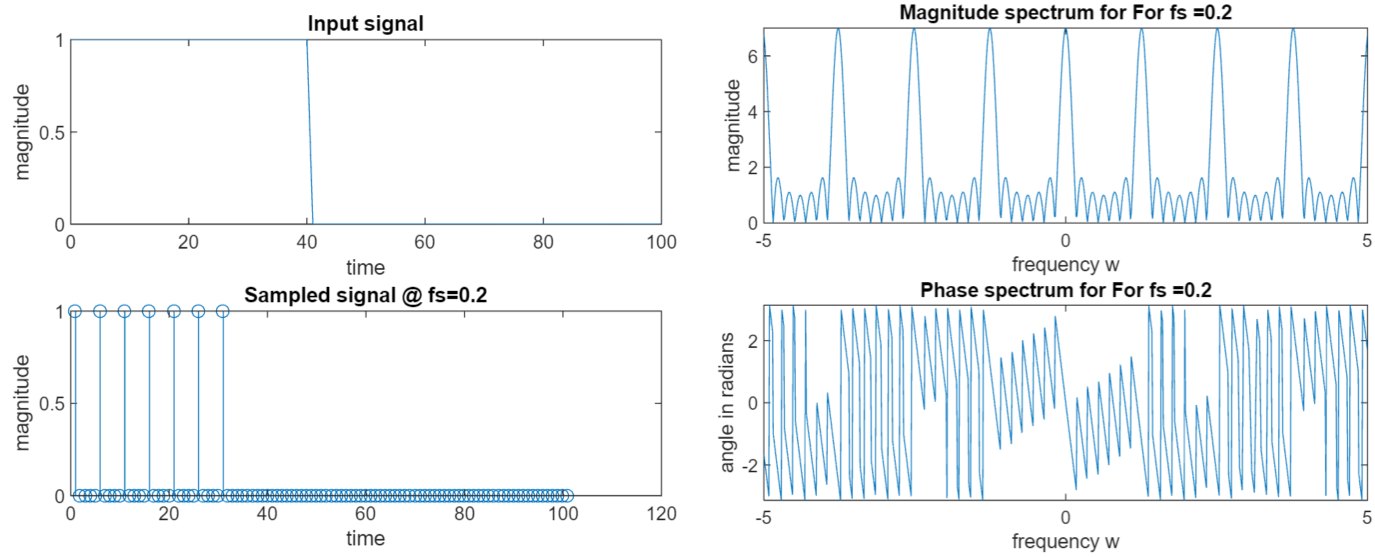
- For the plotting of graphs, I plotted each graph individually and took screenshot and pasted on the report. Since the code is very big I did not keep it here.

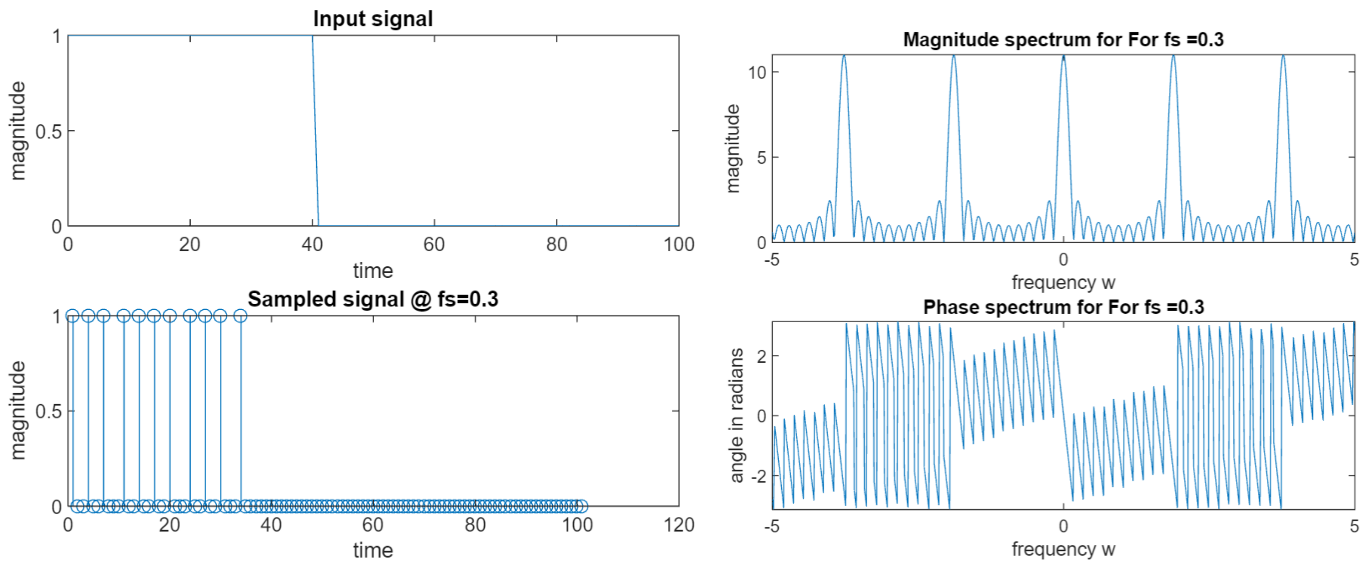


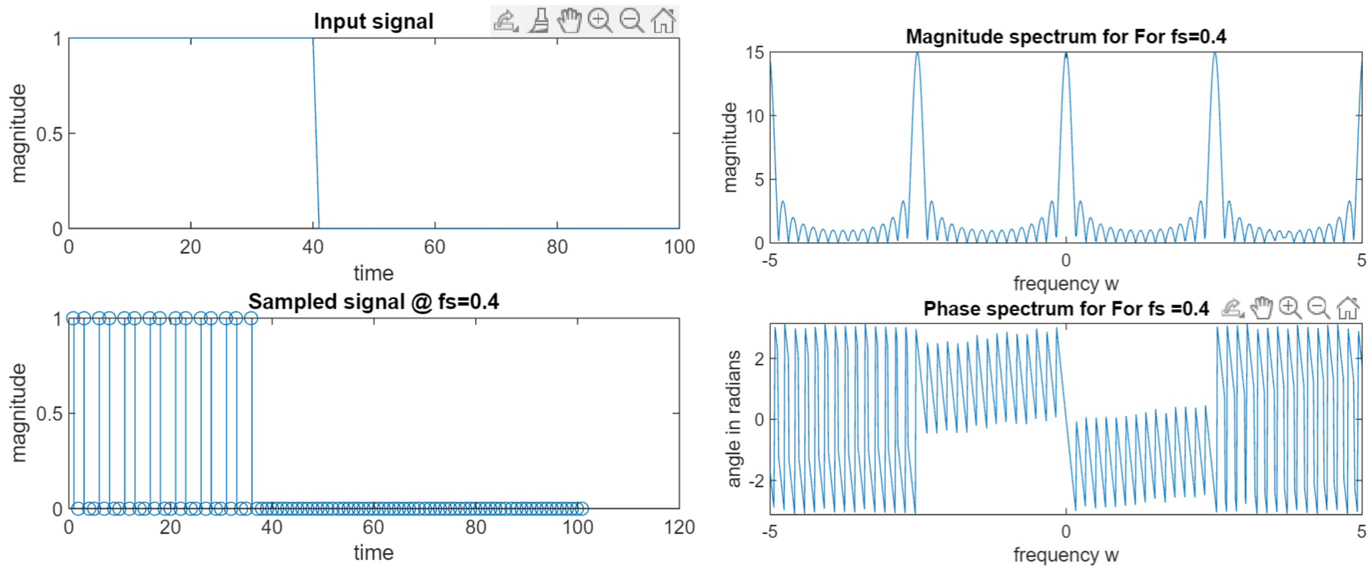







Input signal
magnitude
time
Sampled signal @ fs=0.2
magnitude
time
Magnitude spectrum for For fs =0.2
magnitude
frequency w
Phase spectrum for For fs =0.2
angle in radians
frequency w


Input signal
magnitude
time
Sampled signal @ fs=0.3
magnitude
time
Magnitude spectrum for For fs =0.3
magnitude
frequency w
Phase spectrum for For fs =0.3
angle in radians
frequency w


Input signal
magnitude
time
Sampled signal @ fs=0.4
magnitude
time
Magnitude spectrum for For fs=0.4
magnitude
frequency w
Phase spectrum for For fs =0.4
angle in radians
frequency w

- The magnitude and phase spectrum should be in between -Π to Π. But here I extended it – 5 to 5 to see the clear graphs for their symmetry over Y-axis and periodicity.

PROBLEM STATEMENT -02

Consider the sampled discrete signal

$$x(n) = 1 \qquad 0 \leq n \leq L$$
$$= 0 \qquad \text{otherwise}$$

Write a program for N – point DFT

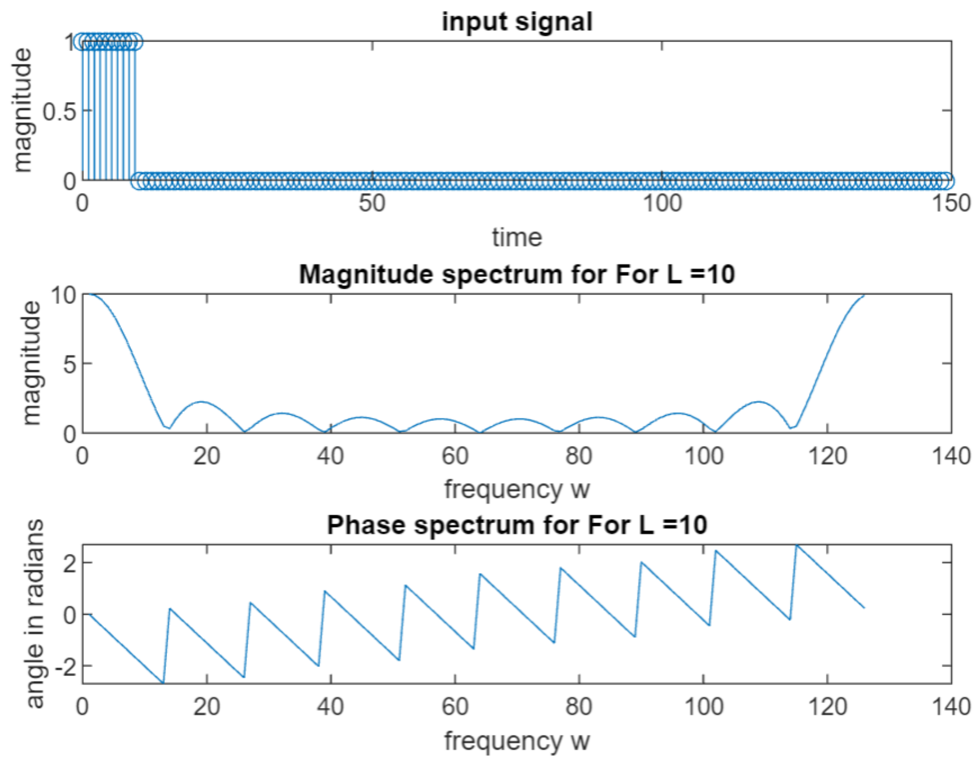
[a] Fix N = 126. Plot the DFT spectrum (magnitude and phase) for L=10, L=40, L=100 and L=128.

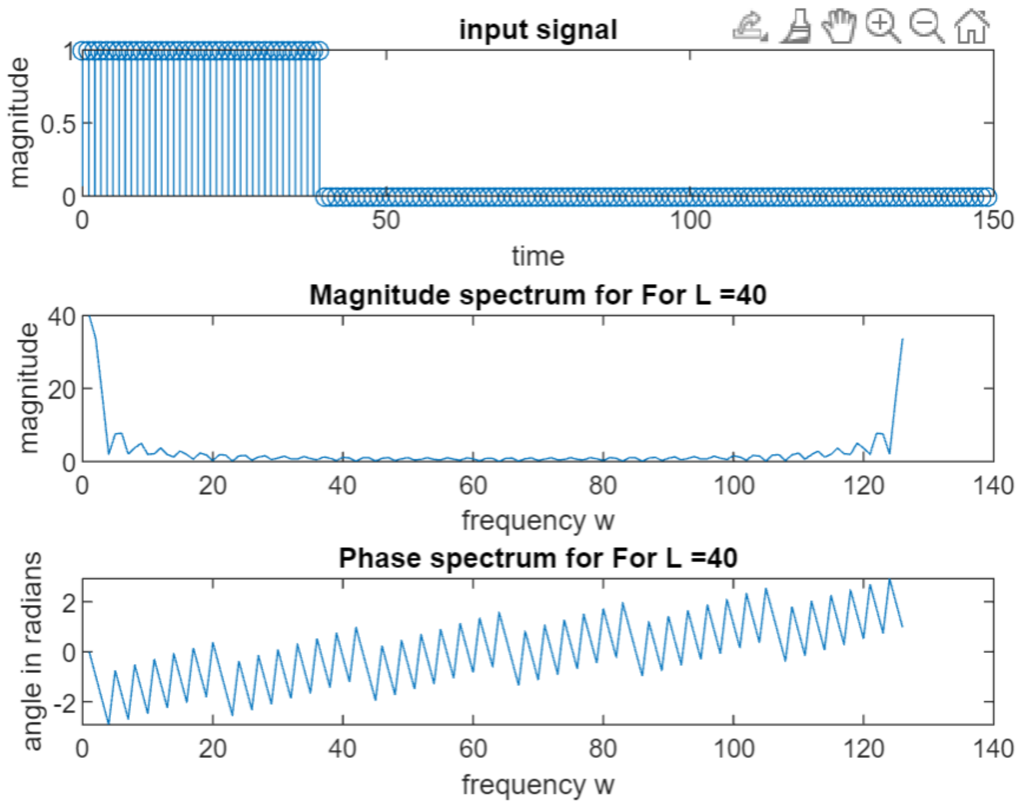
[b] Fix L =40, plot the DFT spectrum (magnitude and phase) for N=128 N= 256 and N=512. Comment on the result.

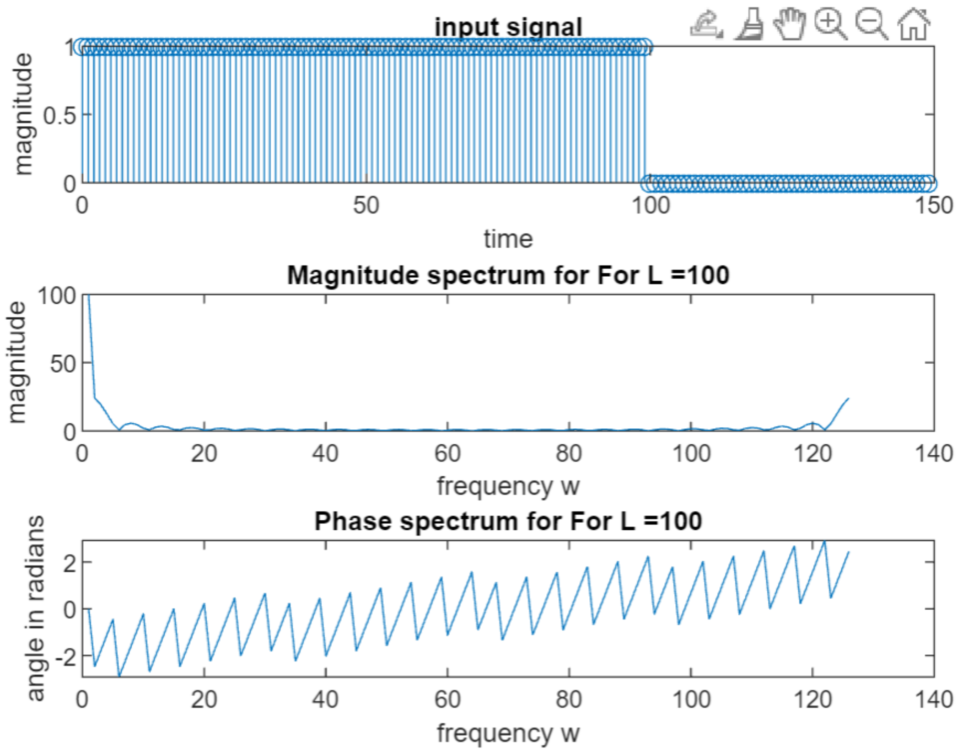
a) N =126

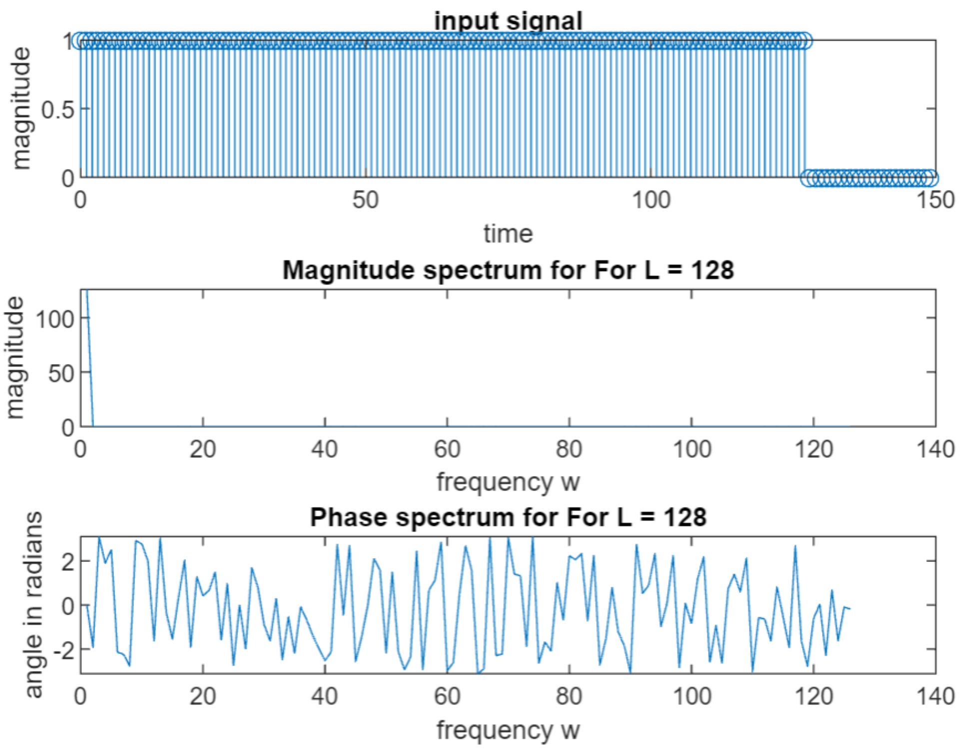
```
% 2-a
clc;
n= 0:149;
N = 126;
L =[10 40 100 128]; %varying the L
x = insig(n,L); % creating a discrete signals with different lengths.
                % size 4 x 150 since there ar e 4 different lenghts.

%calculating DFT

% X(k) = ∑_x(n)*e^((-j2πkn)/N)
% k varies from 0 to N-1
% n varies from 0 to N-1

for i= 1:length(L)
    for k = 0:N-1
        s=0;
        for j = 0:N-1
            s = s + x(i,j+1).*exp(-1i*2*pi*k*j/N);
        end
         Y(i,k+1) = s;
    end
end


figure()
subplot 311
stem(n,x(1,:)),xlabel("time"),ylabel("magnitude"),title("input signal")
subplot 312
plot(abs(Y(1,:))),xlabel("frequency w"),ylabel("magnitude"),title("Magnitude
spectrum for For L =10");
```

```
subplot 313
plot(angle(Y(1,:))),xlabel("frequency w"),ylabel("angle in radians"),title("Phase spectrum for For L =10")


figure()
subplot 311
stem(n,x(2,:)),xlabel("time"),ylabel("magnitude"),title("input signal")
subplot 312
plot(abs(Y(2,:))),xlabel("frequency w"),ylabel("magnitude"),title("Magnitude spectrum for For L =40");
subplot 313
plot(angle(Y(2,:))),xlabel("frequency w"),ylabel("angle in radians"),title("Phase spectrum for For L =40")

figure()
subplot 311
stem(n,x(3,:)),xlabel("time"),ylabel("magnitude"),title("input signal")
subplot 312
plot(abs(Y(3,:))),xlabel("frequency w"),ylabel("magnitude"),title("Magnitude spectrum for For L =100");
subplot 313
plot(angle(Y(3,:))),xlabel("frequency w"),ylabel("angle in radians"),title("Phase spectrum for For L =100")

figure()
subplot 311
stem(n,x(4,:)),xlabel("time"),ylabel("magnitude"),title("input signal")
subplot 312
plot(abs(Y(4,:))),xlabel("frequency w"),ylabel("magnitude"),title("Magnitude spectrum for For L = 128");
subplot 313
plot(angle(Y(4,:))),xlabel("frequency w"),ylabel("angle in radians"),title("Phase spectrum for For L = 128")


% function for creating the discrete time signals based on lenghts

function y = insig(n,L)
    y =zeros(length(L),length(n));
    for i=1:length(L)
        for j=1:length(n)
             if(n(j)<=L(i)-1)
             y(i,j) =1;
             else
            y(i,j)=0;
              end
        end
    end
end
```


input signal
magnitude
time
Magnitude spectrum for For L =10
magnitude
frequency w
Phase spectrum for For L =10
angle in radians
frequency w


input signal
magnitude
time
Magnitude spectrum for For L =40
magnitude
frequency w
Phase spectrum for For L =40
angle in radians
frequency w



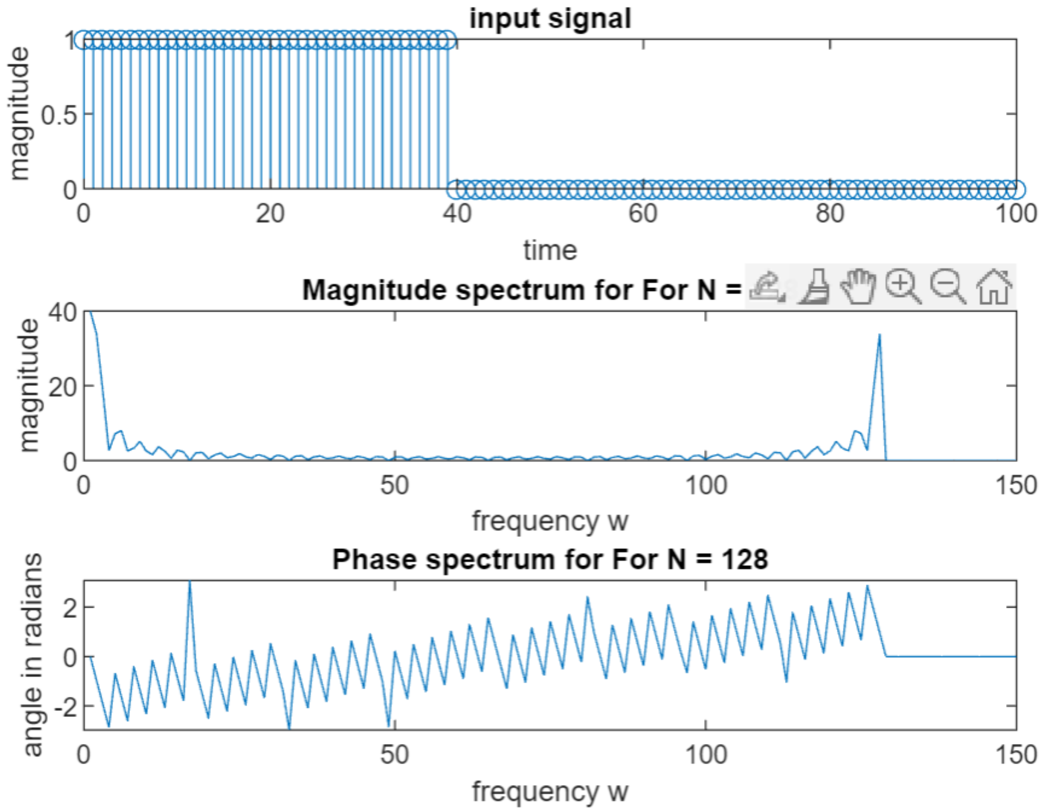


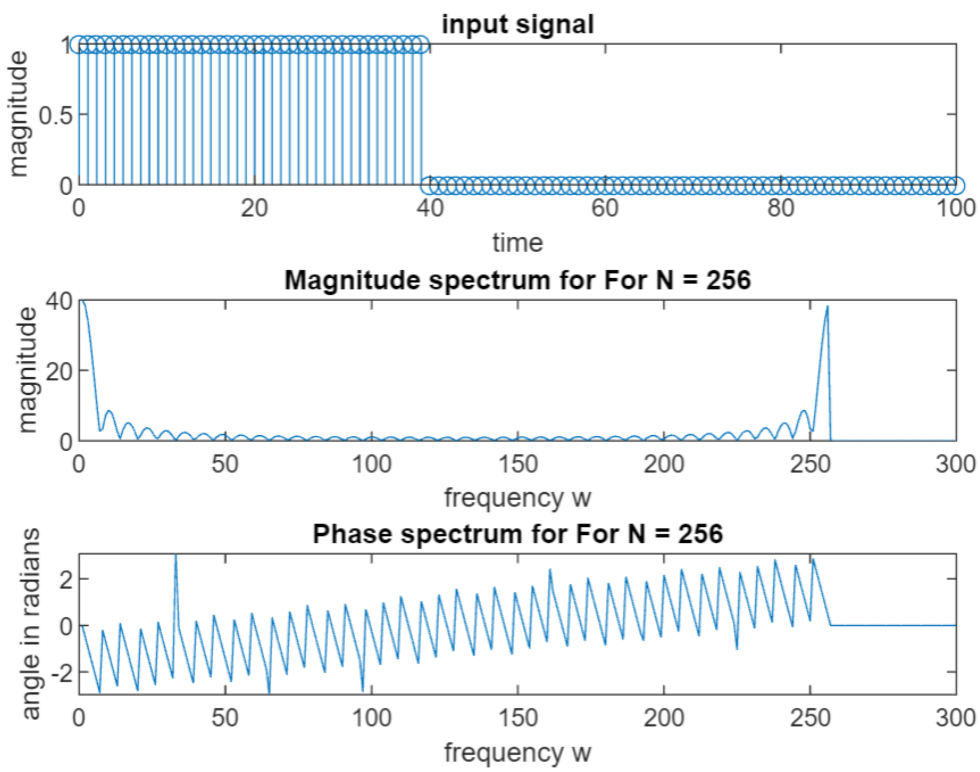
b) Taking L =40

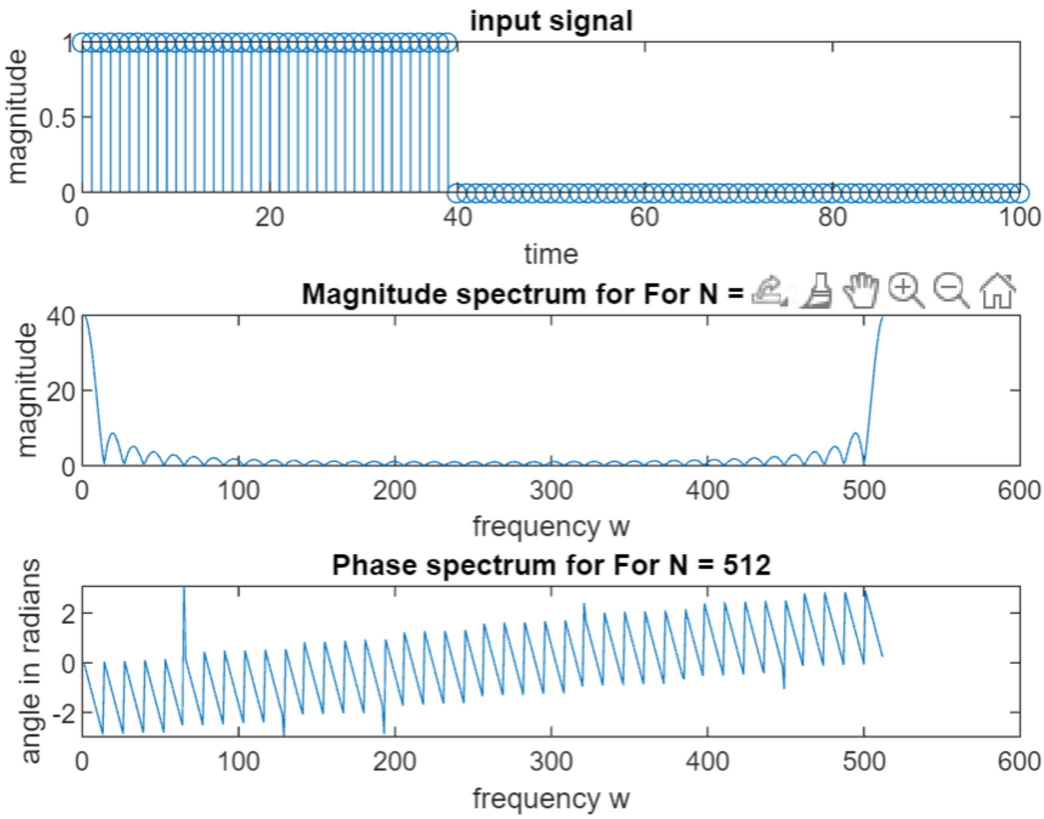
```
% 2-b
clc;
n= 0:519;
N = [128 256 512];
L = 40;

x = insig(n,L,N) ;
% creating a discrete signals with different lengths.
```

```
                % size 4 x 150 since there are 4 different lengths.

%calculating DFT

% X(k) = ∑_x(n)*e^((-j2πkn)/N)
% k varies from 0 to N-1
% n varies from 0 to N-1

for i= 1:length(N)
    for k = 0:N(i)-1
        s=0;
        for j = 0:N(i)-1
            s = s + x(i,j+1).*exp(-1i*2*pi*k*j./N(i));
        end
         Y(i,k+1) = s;
    end
end

figure()
subplot 311
stem(n,x(1,:)),xlim([0 100]),xlabel("time"),ylabel("magnitude"),title("input signal")
subplot 312
plot(abs(Y(1,:))),xlim([0 150]),xlabel("frequency
w"),ylabel("magnitude"),title("Magnitude spectrum for For N = 128");
subplot 313
plot(angle(Y(1,:))),xlim([0 150]),xlabel("frequency w"),ylabel("angle in
radians"),title("Phase spectrum for For N = 128")


figure()
subplot 311
stem(n,x(2,:)),xlim([0 100]),xlabel("time"),ylabel("magnitude"),title("input signal")
subplot 312
plot(abs(Y(2,:))),xlim([0 300]),xlabel("frequency
w"),ylabel("magnitude"),title("Magnitude spectrum for For N = 256");
subplot 313
plot(angle(Y(2,:))),xlim([0 300]),xlabel("frequency w"),ylabel("angle in
radians"),title("Phase spectrum for For N = 256")

figure()
subplot 311
stem(n,x(3,:)),xlim([0 100]),xlabel("time"),ylabel("magnitude"),title("input signal")
subplot 312
plot(abs(Y(3,:))),xlabel("frequency w"),ylabel("magnitude"),title("Magnitude spectrum
for For N = 512");
subplot 313
plot(angle(Y(3,:))),xlabel("frequency w"),ylabel("angle in radians"),title("Phase
spectrum for For N = 512")

% function for creating the discrete time signals based on lengths
function y = insig(n,L,N)
    y =zeros(length(N),length(n));
    for i=1:length(N)
        for j=1:length(n)
             if(n(j)<=L-1)
             y(i,j) =1;
             else
            y(i,j)=0;
              end
```

```
            end
        end
    end
```


input signal
magnitude
time
Magnitude spectrum for For N =
magnitude
frequency w
Phase spectrum for For N = 128
angle in radians
frequency w


input signal
magnitude
time
Magnitude spectrum for For N = 256
magnitude
frequency w
Phase spectrum for For N = 256
angle in radians
frequency w



Conclusions:

- For the case of constant sampling frequency and different T values, as the value of T increases, in Magnitude spectrum, the bandwidth decreases and the magnitude of the peak also increases. The distance between each peak also increased. And also no. of clusters from $-\pi \; to \; \pi$ also increases. Also, the phase spectrum comes closer as the T value increases.
- For the case of constant T and varying values of sampling frequency, as the value of sampling frequency increases Magnitude of each peak increased and distance between each peak also increased. The no of clusters between each peak also increased. Also, the phase spectrum comes closer as the T value increases.

- For the DFT question, For the case of constant N and varying the value of L, as the value of L is increased, the no. of bands in the space of N are increased and peak magnitudes are increased. For the case of constant L and varying the value of N, as the value of N is increased the spectrum length is increased but the peak value pf spectrum is constant. Therefore, we can infer that length of spectrum depends on N and Peak value depends on L.